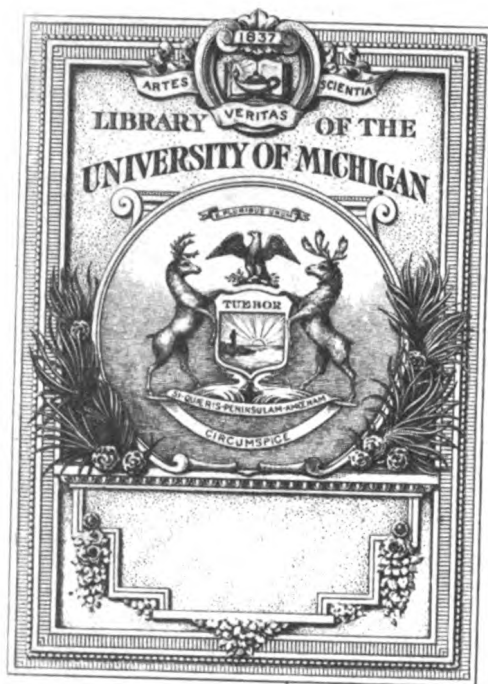


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AND PSYCHIATRY

FROM THE

PATHOLOGICAL LABORATORY

OF THE

LONDON COUNTY MENTAL HOSPITALS,  
MAUDSLEY HOSPITAL, DENMARK HILL.

EDITED BY

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## PREFACE.

Since the publication of the last volume of the Archives, the pathological laboratory of the London County Mental Hospitals has been removed from Claybury to the Maudsley Hospital, Denmark Hill, S.E.

When this hospital was completed it was taken over by the War Office for the 4th London General Hospital, of which it forms the principal part of the neurological section.

The pathological laboratory of the hospital at first was used only for County Council work, but during the last year a part of the laboratory has been utilised by Sir Ronald Ross for investigations on malaria.

Besides the ordinary routine work of Wassermann and Widal reactions, with an occasional report on pathological material, the investigations have been entirely interrupted by necessary demands of military service.

My first assistant, Captain Moodie, M.D., has been in charge of a mobile pathological laboratory at the front for more than three years. Captain Sydney Mann, another assistant, has been in charge of a pathological laboratory at Alexandria for two years. The only assistant I have left is Mr. Geary, who has carried on the work of the Laboratory and is indispensable for the routine work and the researches carried on in the Laboratory. In fact, he received a badge from the Ministry of Munitions in order that the laboratory work connected with the war could be carried on.

Dr. Sano, who received a grant from the Medical Research Committee, has completed his researches on the convolitional pattern of the brains of relatives, and these are published in this volume.

Also, from the Proceedings of the Royal Society of Medicine are republished the works of Fleet Surgeon Kojima carried out at the Claybury Laboratory. Likewise the work carried out by the late Dr. Laura Forster who died in Galicia.

The remaining publications in the volume relate to published lectures and researches carried out by myself during the last two years. I here desire to acknowledge the assistance afforded me by Mr. Geary, and by Miss Munro and by Miss Watson. The remuneration for these two ladies' work

was provided by a government grant from the Board of Control ; in fact, the money paid by the Medical Research Committee and the Board of Control have more than provided for the sum expended in publishing this volume, which consists entirely of articles republished from other journals. The initial cost of illustrations of these papers would have been very heavy had they not first appeared at the expense of other journals.

Other researches which I had in hand have necessarily given place to those connected with the war. Such are the causation of shell shock, gas poisoning, and war-neuroses.

In connection with the valuable work being carried on in the Hospital, a number of American medical officers skilled in Neurology, have come to study the war psycho-neuroses in this hospital under my direction ; and I have much pleasure in stating that they have afforded me very great assistance in writing the reports and in the treatment of the cases.

Recently Major Professor Marinesco, of Bucharest, one of the most distinguished neuro-pathologists in Europe, has by the aid of a grant of the Medical Research Committee, undertaken a number of important researches in connection with painful neuromata (in connection with Capt. Corner, R.A.M.C., T., of the Roehampton Orthopædic Hospital) and upon the relation of oxidases to the functions of the nervous system in health and disease. I feel certain that these researches are likely to be associated with important results.

FREDERICK W. MOTT.

*January, 1918.*

[*Reprinted from the* PROCEEDINGS OF THE ROYAL SOCIETY OF MEDICINE,  
1915, Vol. VIII (*Section of Psychiatry*), pp. 1—16.]

## Section of Psychiatry.

January 26, 1915.

Dr. F. W. MOTT, F.R.S., President of the Section, in the Chair.

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### PRESIDENTIAL ADDRESS.

#### The Application of Physiology and Pathology to the Study of the Mind in Health and Disease.

IN his illuminating work on Mental Physiology Dr. Maudsley thus comments on the subject which I have ventured to take for my address to you this evening, in the chapter, "The Method of the Study of Mind," p. 48:—

"The past history of Psychology—its instinctive progress, so to speak—no less than the consideration of its present state, proves the necessity of admitting the objective method of the study of mind. That which a just reflection teaches incontestably, the present state of physiology illustrates practically. Though very imperfect as a science, physiology has made sufficient progress to prove that no psychology can endure except it be based upon its investigations. Let it not, moreover, be forgotten (as it is so apt to be) that there is continuity throughout Nature, and the divisions in our knowledge are artificial; that they should be accepted and used rather, as Bacon says, for lines to mark and distinguish than sections to divide and separate; in order that solution of continuity in sciences may always be avoided."

This was written nearly fifty years ago, and physiology has made notable advances, yet one must still agree with the further statement of Maudsley that no one pretends that physiology can for many years to come furnish the complete data of a positive mental science. We can, however, realise that physiological science has made great advances in its application to the study of mind, and in no direction more important than in the bio-chemistry of the ductless glands, and the influence of their internal secretions (hormones) on the bodily and mental functions in health and disease, an addition to knowledge which

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we owe in greatest measure to English physiologists. It will be my endeavour this evening especially to direct your attention to the desirability of the application of this branch of physiology to psychiatry. This influence of internal secretions on the mind was alluded to by Maudsley in his "Physiology of the Mind," and it is interesting to see how this modern development of the hormone theory is anticipated by him in the following lines :—

"It is probable that many vague feelings or indefinite emotional states to which we have no adequate or corresponding ideas are produced by the operations of the internal organs; they are of a very vague character, and cannot be expressed in definite objective signs, wherefore they cannot become knowledge. We have the best instances of what I mean in the vague, overmastering feelings of pregnancy, and those to which the development of puberty gives rise; and it is certain that we must go deeper than self-conscious analysis will ever get, to arrive at their true nature and causation. Even the passion of love itself has its source in the unconscious life and can no more be explained in consciousness than the feelings of hunger and thirst; it marks an elective affinity in the organism which oftentimes enslaves consciousness and overpowers volition."

There is reason to believe that each internal organ of the body has its representative centre in the supreme cerebral centre, through which it takes its essential part in the constitution and function of the mind. Maudsley further says :—

"Now the brain is the leading member of this physiological union, the centre in which the different organic functions meet and are co-ordinated; wherefore the supposition that it carries on this important function of organic life quite apart from and independently of its function as the organ of mind, would be most improbable, even if observation did not contradict it. As a matter of fact, observation does contradict it positively. We have the plainest instance of this in the case of the reproductive organs, the functional development of which, taking place somewhat abruptly at puberty, works a complete revolution in the mental character. The individual is transformed, his entire sentiency is changed, and he becomes susceptible to impressions which before were completely indifferent to him: a look, a tone, an odour, a touch arouses an emotion which is quite new to him, and sympathetic ideas come he knows not whence or how. Strange and vague feelings, aimless longings, obscure impulses and novel ideas witness to the commotion which the newly developed function is making by its eruption into the mental life; there is an awakening of sensual impulses which clothe themselves in mental forms, of mental necessities which clothe themselves in sensual images. It is now, too, that altruistic feeling begins to germinate in the mind; before puberty a boy is the most complete egoist, taking as a matter of course all the affection and care

which are lavished upon him ; but after puberty he begins for the first time to have some sense of what others do for him, and to display some feeling of his obligation to them. These evolutionary effects of the functional development of the reproductive organs do not take place when such development is prevented by their removal before puberty."

What a splendid analysis Maudsley has thus given of the complete revolution of the mind at puberty, and how well he has indicated the importance of a full investigation of the histology of the sexual glands in health and disease in relation to the study of insanity.

Nature is unmindful of the individual, mindful only of the species, and the sexual impulse is the strongest of all physiological impulses. It is true that at the dawn of the passion "love is blind." It is blind because the sexual impulse is excited by a bio-chemical stimulus derived from the internal secretion of the sexual glands, arousing vague instinctive desires which, as Maudsley says, have their source in the unconscious life, and which work a complete mental revolution. But if love is blind, it is also true that "love adds a precious seeing power to the eye." This is apparently paradoxical, but the latter is not a biological antithesis to the former, for the latter implies a perceptual instinct of sexual attraction necessary to materialise the bio-chemical stimulus and effect the preservation of the species. That this perceptual attraction is instinctive is shown by the fact that the language of love is universal ; it cannot be concealed where it exists ; it cannot be feigned where it does not exist ; it appeals by mute eloquence in expression, attitude, and eye in a manner more enticing and forcible than any spoken language. Yet the sexual impulse is the one that is subjected to the greatest amount of repression on account of the mental attitude of society, and for that reason it has always been one of the weakest points in our cultural development. Freud and his school assert that feelings of a sexual nature appear before puberty, and the newborn child brings with it the germs of sexual feelings, which continue to develop for some time, and then succumb to a progressive suppression, which is in turn broken through by the proper advance of sexual development, and which can be checked by individual idiosyncrasies. I do not propose to discuss the Freudian doctrines here, but later I shall bring forward some evidence of a histological nature in support of the above statement.

It must have struck everybody that has had to do with insanity that there are two periods of life when its onset specially occurs—namely, early adolescence and the involutional period. In the study of the

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relation of heredity to insanity I was particularly struck by this fact. Now are we to assume that the mental disorder of the true insanities or psychoses, even those which terminate in dementia, as dementia præcox, can be explained by structural changes of the brain, macroscopic or microscopic? Or should we not rather believe that they are either the result of microbial toxic conditions of the blood, or, where this cause is improbable, due to disturbance of the physiological equilibrium of the internal secretions of the ductless glands, which experiments on animals and clinico-anatomical investigations in man have shown play an all-important part in the healthy functioning of body and mind? Moreover, we have in recent years learnt that the interstitial gland structure of the sexual organ can function independently of the genetic gland structure; and there is abundant proof to show that functionally correlated with the sexual glands are the thyroid, the parathyroid, the hypophysis, the pineal gland, the cortical portion of the suprarenal gland, the thymus, and probably also the islands of Langerhans of the pancreas. Therefore, to study the relation of a disorder of the internal secretions to various forms of insanity it is necessary to make a systematic examination of all these glands in health and disease at various age-periods from birth onwards; for this purpose it was necessary for comparison to collect material and obtain the various organs from hospital and asylum cases, dead from injury, and acute and chronic bodily disease accompanied and unaccompanied by mental disorder. An investigation of this material in a systematic manner must be made before any just conclusion can be arrived at in respect to the correlation of a disturbance of equilibrium of the internal secretions of the reproductive gland system and insanity. Already I have observed a remarkable variation in the weight of the thyroid gland, especially in women, 4.1 grm. the lowest and 51 grm. the highest.

#### HYPOTHYROIDISM IN RELATION TO THE SEXUAL GLANDS AND HORMONE EQUILIBRIUM, AS A CAUSE OF BODILY AND MENTAL DISEASE.

I have already obtained many objective indications pointing to close association of mental disease with disease of the ductless glands; thus I brought before this Section and published, in conjunction with Dr. Brun, an account of "A Microscopical Investigation of the Nervous System in Three Cases of Spontaneous Myxœdema."<sup>1</sup> One of these was a case dying in Claybury Asylum, of special interest because it

<sup>1</sup> *Proc. Roy. Soc. Med.*, 1913, vi (Sect. of Psych.), pp. 75-100.

showed a marked increase of lymphoid and fibrous tissue with nearly complete absence of colloid in the thyroid gland. There was a substitutive increase of colloid in the parathyroid, and especially an increase of colloid of the *pars intermedia* of the pituitary. The objective signs of myxœdema were slight in this case when the marked destructive change of the thyroid glandular substance is considered, but the mental disorder was pronounced. She died of heart failure, with a pulse-rate of only 40. Examination of the central nervous system showed marked chromolytic changes of the nerve cells, affecting in a particularly grave manner the autonomic bulbar system—viz., the nuclei of the ninth and tenth nerves, and in a less degree the cerebrospinal motor neurones, and the sympathetic system. Dr. Brun and I called attention to the comparatively frequent coincidence of the myxœdematous syndrome with an acute psychosis, starting suddenly (as in two of the cases we reported), and having for the most part the characters of a melancholic or a manic-depressive insanity.

#### THE BIO-CHEMICAL INTER-RELATION OF THE SEXUAL GLANDS AND THE DUCTLESS GLANDS.

There are many facts pointing to the bio-chemical inter-relation of the sexual glands and the ductless glands; thus it is known that the thyroid glands increase in size during pregnancy; there is, indeed, a distinct hypertrophy occasioned by a marked increase of colloid in the follicles. The development of the corpus luteum and the passage of its hormone into the blood is probably the cause of the hypertrophy. An increase of the thyroid occurs at puberty, during menstruation and at the climacterium. Changes also occur in the parathyroids during pregnancy. In the anterior glandular portion of the hypophysis, certain cells which normally occur in the gland are greatly increased and constitute the so-called pregnancy cells, which structural increase is partly the cause of the increase of weight of the gland in pregnancy. A large increase of the lipoid cholesterin ester content of the cortical cells of the adrenal gland occurs, and it is of interest to note that these cells structurally and chemically closely resemble the lutein cells of the Graafian follicle. Indeed, it has been suggested, and there is considerable evidence in support thereof, that we must not only look to a toxæmia caused by derangement of the function of the liver and kidneys to explain the occurrence of vomiting, eclampsia and mania in pregnancy, but also to the probability that these pathological conditions may result

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from a disturbance of the physiological equilibrium of the internal secretions. Again, this disturbance of the balance of the internal secretions which is liable to occur at the menopause may be the cause of the frequent occurrence of psychoses and neuroses of various kinds so frequently met with in women for the first time. I shall later, when referring to the development of the sexual glands, point out other facts in support of the bio-chemical functional inter-relation of the sexual and ductless glands.

### OBSERVATIONS MADE UPON THE SEXUAL GLANDS IN RELATION TO INSANITY.

Since the war began I have made all the post-mortem examinations myself instead of having them done by my assistant, and I have been in the habit of examining all the ductless glands. In conjunction with Staff-Surgeon Kojima, who has carefully weighed and preserved the glands, we have obtained some valuable material for the pursuit of this investigation of the relation of the sexual and ductless glands to insanity. I have sometimes found, after removing the brain, that the pituitary gland is enlarged, and then I have found that the thyroid shows either fibrotic atrophy or the gland substance has been replaced by fibroid and lymphoid tissue; and I may here remark that the thyroid may be of normal size, and yet contain no glandular substance; so that microscopic examination is necessary to reveal the extent of the disease. When I speak of enlargement of the pituitary I do not mean a tumour. I have frequently observed in cases of hypothyroidism that the ovaries have appeared fibrotic and atrophied, or have undergone cystic degeneration, as happened in the following case:—

A married woman, aged 57 on admission, who was said to be a dancer. Her speech was said to be slow and indistinct; she had tremors of face, hands and tongue. The memory was impaired and she had no idea of time or space. She was very depressed and attempted suicide before admission. She remained emotional and depressed and became demented, so that before death, nine years later, she was regarded as suffering from general paralysis. At the post-mortem examination, which I made a few days ago, I found no signs of brain disease apparent to the naked eye; it was certainly not a case of general paralysis. I observed that the *sella turcica* was very large, and the posterior clinoid processes were absorbed; the gland weighed 1.2 grm., which is more than twice the normal weight, and it was



especially the posterior lobe and *pars intermedia* that was increased so much in size. As I expected, I found the thyroid very atrophied and fibrotic, weighing only 12·6 grm. The interesting feature of the case was the finding of an infantile uterus; the left ovary completely destroyed by an old salpingitis, and the right one atrophied and damaged to such a degree that it weighed only 0·4 grm. I consider it probable that this patient early in life had suffered from gonorrhœa, which had caused ovarian destruction, atrophy of the uterus, and at the climacterium hypothyroidism, with substitutive increase of the colloidal *pars intermedia* of the pituitary. Microscopic examination of the thyroid gland showed a marked fibrosis and atrophy of the glandular substance; there was still some colloid present. In one of the cases of myxœdema which presented during life very pronounced objective and subjective signs and symptoms, I found a somewhat similar condition of the gland. In another case—that of a patient admitted to Claybury—who on admission showed signs of myxœdema, but died eight years later without the objective signs and symptoms being pronounced, but from the first had very marked mental symptoms, I found at the autopsy, made a few weeks ago, a large thyroid. This on microscopic examination exhibited only fibrous and lymphoid tissue, the gland was almost completely destroyed, and the pituitary gland was nearly twice the normal weight.

Now it is possible that the increase in size of the pituitary gland may have an important bearing in the production of the mental symptoms, for it is known that the colloidal substance secreted by the *pars intermedia* escapes through the infundibulum and the neurohypophysis into the cerebrospinal fluid. What part this internal secretion precisely plays we do not know; but if the cerebrospinal fluid serves as the lymph of the brain, as I believe it does, then the excess of this colloid pouring into the fluid which irrigates the perineuronal spaces may have an important influence upon the functions of the organ of mind. However, a great deal of work will have to be done before this can be more than suggested as a possible working hypothesis.

#### SYSTEMATIC EXAMINATION (BY DR. LAURA FORSTER) OF A LARGE NUMBER OF OVARIES IN DIFFERENT FORMS OF MENTAL DISEASE.

For years I had been struck with the fact that the ovaries of women suffering from insanity at an early age, and dying in early or late adolescence, have, at the autopsy, been found to be fibrotic. Knowing as we do that amenorrhœa is frequently met with in such young

women, I thought it would be desirable to have a systematic investigation made of the ovaries, and Dr. Laura Forster undertook and completed an investigation of the ovaries by serial sections in a hundred cases, for the most part obtained from persons who had died in the asylums, but also some at varying ages who had died in hospitals. As regards dementia præcox, she found that the ovaries of all those who had reached the age of 30 showed signs of early involution, by an increase of interstitial connective tissue, and there was a great scarcity of Graafian follicles. Even in those much below this age there was a distinct diminution of the follicles as compared with a normal woman of the same age. In imbecility with or without epilepsy the ovaries did not present a uniform type. Some quite young persons showed early involution, while in others there were a proportionately large number of follicles. In mania depressiva she found a diminution in the number of follicles. Thus in the ovary of a woman, aged 23, there were signs of the ovary undergoing cystic degeneration, and a marked increase of fibrous tissue. In general paralysis, women are not virgins, because, except in the case of the juvenile form, they are the subjects of acquired syphilis, and the mental disease is the result of infection of the brain. The ovaries of young women dying of this disease do not show early involution as a rule.

The results of this careful and laborious investigation of the ovaries in relation to mental disease are in a measure nullified for the following reasons: Dr. Forster herself showed that a young woman dying of chronic heart disease in a hospital, presumably without any mental affection, exhibited fibrotic changes in the ovaries similar to those observed in cases of primary dementia of adolescence. Dr. Forster has not separated her asylum cases dying from some acute bodily disease from those who have died of tuberculosis, or some other chronic disease usually met with as a cause of death in the subjects of dementia præcox. Consequently we do not know whether the changes described are due to the chronic bodily disease, or are to be associated with the mental defect. In her paper, which I hope to publish later, she has laid considerable stress upon the experiments of Ceni upon birds, in support of the correlation of dementia præcox with changes found in the ovaries. He removed one hemisphere, and the birds surviving the traumatic shock were killed after varying periods of a few months to three years, and their ovaries were subsequently examined histologically. The primary shock had the effect of causing them to cease laying eggs for some months. In the following year they began to lay again, but

in the second year fewer eggs were laid, or the birds ceased altogether from laying. The birds were otherwise in a healthy condition. The examination of the ovaries showed a premature progressive involution. Ceni concludes that there are intimate relations between the brain and the ovary. It would have been interesting if Ceni had conducted similar experiments on male birds, and proved that lesions of the brain can produce a premature dynamic exhaustion of the testis. And that leads one to say that Dr. Kojima and I are systematically investigating the male reproductive system and ductless glands. For if an abnormal condition of the sexual glands and of the internal secretions of the ductless glands, causing an hormone failure or disorder of the hormone equilibrium, has a causative relation to dementia præcox, it should be possible to establish a structural defect or change in the corresponding reproductive organs and ductless glands of the male. The work of Miss Forster at present, therefore, may be regarded as highly suggestive, but not affording convincing proof. The work she has begun, however, will now be extended in a systematic manner by Dr. Kojima.

I was fortunate enough recently to obtain a case of dementia præcox who died of pneumonia after a few days' illness, and whose bodily condition prior to this, judged by the appearance of the organs, must have been sound. The ovaries in this case were fibrotic and showed very few follicles or corpora. So that it seems probable that there may be some correlation, if not causative relation, between the hypo-function of the ovaries and an insanity of adolescence terminating in dementia. Seeing that the sexual glands are fundamentally the *fons et origo* of the passions, a hypo-function of them might, by the absence of the hormones, account for the *emotional* indifference so characteristic of this form of mental disease.

Again, my investigations of insane parents with insane offspring show that the children of insane parents when they become insane do so in a large proportion of cases in adolescence. Anticipation thus tends either to elimination of the unsound members by bringing it on at an earlier age or by a diminished durability of the germinal cells.

#### MICROSCOPICAL EXAMINATION OF THE SEXUAL GLANDS FROM BIRTH ONWARDS.

An examination of the ovaries and testes at different ages from birth onwards has proved to be very interesting from several points of view. In that admirable text-book, the "Principles of Human Physiology," of Professor Starling, ovulation is thus described (p. 1366):—

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“At birth the ovary consists of a stroma of spindle-shaped cells, and is covered by a layer of cubical epithelium (the germ epithelium) continuous with the epithelium lining the general peritoneal cavity. Embedded in the stroma, but especially numerous just underneath the epithelium, are a vast number of ‘primordial follicles.’ These are formed during the foetal life by down-growths of the germinal epithelium. Of the cells prolonged in this way from the germinal epithelium, some undergo enlargement to form the primordial ova, while the others are arranged as a single layer of flattened nucleated cells, the ‘follicular epithelium,’ as a sort of capsule to the ovum. Of the primordial follicles, about 70,000 are to be found in the ovary of the newborn child. During the first twelve to fourteen years of life they remain in a quiescent condition. With the onset of puberty one or more of the follicles begin to develop. Indeed, this development may be regarded as the causative factor in the various phenomena which are characteristic of puberty in the female (*vide* p. 1361). The first stage in the growth of the follicle is a proliferation of the follicular epithelium, the cells of which become cubical and are arranged in several layers around the ovum. At one point in the mass of cells surrounding the ovum a cavity appears filled with fluid—the *liquor folliculi*. The epithelium thus becomes separated into two parts—i.e., the *membrana granulosa*, several layers thick, lining the whole follicle, and the *discus proligerus*, a mass of cells attached to one side of the follicle, in which is embedded the ovum. Round the growing follicle the stroma assumes a concentric arrangement and forms a capsule, of which the internal layer consists chiefly of spindle-shaped cells richly supplied with blood-vessels, while the outer layers, the *theca externa*, is made up of tough fibrous tissue. With the growth of the follicle the ovum also becomes larger and surrounds itself with a distinct membrane, the *zona pellucida*.”

It will be observed that Professor Starling considers that the formative growth of a follicle does not occur until puberty. But I have a microscopic drawing of a section of the ovary of a child aged 8 days, and one of a child aged 1 year 3 months, which shows that even a few days after birth the primordial follicles are commencing to undergo development into Graafian follicles and the ovum is being surrounded by actively developing epithelial cells which will later on form the *membrana granulosa*; outside of this are seen large connective tissue cells which will form the *theca interna*, constituting the interstitial gland of Limon. The section of the ovary of the child aged 15 months shows a Graafian follicle quite as well developed in every respect as that described and figured by Professor Starling. Seeing that there are 70,000 ova to be found in the ovary of the newborn child, and during the period of life when pregnancy can occur (12 to 48) not more than 400 follicles can rupture at the menstrual periods, of which there is a possibility of relatively few being fertilised, there is then an extra-

ordinary prodigality of primordial follicles. We cannot, however, believe that the primordial follicles ripen and form Graafian follicles in early life without effecting some useful purpose. Should we regard the epithelial cells of the *membrana granulosa* or the proliferated interstitial cells of the *theca interna* as the source of the hormone that fixes and maintains the secondary bodily and mental sexual characters? The balance of evidence is in favour of the thecal cells secreting the hormone that fixes the secondary sexual characters, and of the view that the development of the Graafian follicles leads to a formative proliferation of the thecal cells in the stroma of the gland. The ovum does not escape from these follicles developed in early life, but degenerates. Subsequently an invasion of the fibrous stroma occurs to form the atretic follicle. I have a photograph of an atretic follicle from the same section of the ovary of a child aged 18 months, also from the ovary of a congenital imbecile and a case of melancholia.

Sections of the testis at various ages prior to puberty show the seminiferous tubules surrounded by an interstitial tissue. The tubules are lined by cells which are called the syncytium of Sertoli, and within this layer of cells are the generative cells, the spermatogonia from which the spermatozoa are developed. There are many reasons for asserting that the internal secretion which fixes and determines the secondary mental and bodily male sexual characters is derived from the interstitial cells (the cells of Leydig as they are called), and which are homologous with the cells of the *theca interna* of the ovary. Among the reasons which may be mentioned are the following facts: (1) Cryptorchids possess the secondary sexual characters, although there is default of development of the generative structure of the gland. (2) Destruction of the generative structure of the ovary and testis by X-rays can be brought about without destruction of the interstitial gland structure; nevertheless, sexual desire and the secondary sexual characters persist.

If we examine the ovary when the genetic function has commenced, a bio-chemical change may be noticed. In the ovary around the follicles that have ruptured are seen the characteristic lutein cells, which in unstained sections appear as pale yellow cells, due to a lipochrome substance similar in composition to the yolk of an egg. If these sections are stained with Scharlach or Sudan III they stain deep red owing to their being full of granules of a fatty cholesterol ester lipoid. I have some coloured drawings which illustrate this appearance. I am not certain whether these lutein cells arise mainly from the interstitial cells or from the epithelial cells of the *membrana granulosa*. They no doubt play an

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important part in the development of the ovum and in the formation of the internal secretion of the corpora lutea. Sections of the ovary prior to puberty show little evidence of lipoid-containing cells; neither do sections of the testis. But, after puberty, not only are the interstitial cells of Leydig loaded with this lipoid, but the lipoid can be seen within the cells constituting the generative structure of the gland. I have a drawing of a section of a seminiferous tubule of a soldier, aged 20, who died from the effects of a bullet wound of the brain in Charing Cross Hospital. It is remarkable that this gland shows little or no evidence of active spermatogenesis. Has the injury to the brain arrested the generative process? All the tubules show an abundant accumulation of lipoid substance, and it is permissible to suppose that this is the raw material out of which the spermatogonia manufacture the nucleinic acid which forms the main constituent of the head of the spermatozoon.

In Carpenter's "Mental Physiology" there is a remarkably interesting chapter on Habit, which is extensively quoted by William James in his "Principles of Psychology." This chapter commences with the following statement:—

"There is no part of man's composite nature in which an intimate relation between Mind and Body is more obvious than it is in the formation of habitual modes of activity, whether psychical or corporeal; the former, like the latter, being entirely conformable to the laws which express the ordinary course of the instinctive operations. In the first place it is characteristic of every living organism to build itself up according to a certain inherited type or pattern, so that we must attribute to its germ a formative capacity in virtue of which it turns to account both the food and the force which it derives from without."

When we reflect that 27,000,000 spermatozoa may be discharged at a single coitus, each one carrying the characters of species, race, and the individual characters of ancestors, we may feel some hesitation in accepting the chromosome or particulate theory of inheritance, and seek for some bio-chemical process by which the male germ cells possess this unlimited power of building up specific living matter.

Ostwald has shown that the heads of the spermatozoa contain a nucleinic acid which is common to all animals, but that each species has a specific protamin ferment, and it may be that this specific protamin is capable of "this formative capacity in virtue of which it turns to account both the food and the force which it derives from without."

## PRECOCIOUS PUBERTY.

It is well known that normal individuals, male and female, may show sexual impulses in early life, and, years before the normal time for puberty, develop the secondary sexual characters. And particularly does this early onset of the reproductive function happen to female natives of hot climates. Apart from this physiological condition there have been recorded a number of remarkably interesting pathological cases of *pubertas præcox*, occurring in both sexes as a result of tumours of the testis, ovary, and pineal and suprarenal glands, which are of great interest in respect to the influence of the internal secretions upon the secondary sexual characters.

Biedl, in his great work on the "Internal Secretions," cites some interesting cases. One was that of a boy reported by Sacchi, who was completely developed as regards the bodily and mental sexual characters at the age of  $9\frac{1}{2}$ . He was 143 cm. in height, weighed 44 kilograms; he had a long black beard and pubic hair well developed. The left testis was greatly enlarged by a tumour which was, on removal, found to be an alveolar sarcoma; following the operation there was a regression of the secondary sexual characters. He also quotes an analogous case in a girl aged 6, where a sarcoma of the ovary had induced a precocious physical and mental development and a menstrual flow. After removal the menses ceased, the hair on the pubes and in the axilla fell out, the mammary glands regressed, and the child-like characters returned in every respect except that of the voice.

Now the pineal body is a glandular structure which in adolescence undergoes regressive changes. We do not know whether these tumours in which precocious puberty occurred were due to hypertrophy of the glandular tissue or were due to a growth which caused its destruction. But Biedl states that basal tumours of the pineal gland of the nature of *teratomata* have been reported as occurring in individuals under the age of 7, who, besides being affected by symptoms of pressure upon the *corpora quadrigemina*, have presented symptoms of precocious mental development. The secondary sexual characters were developed at an early age. In the Department of Neurology at the Cornell University "The Functions of the Pineal Gland" have been recently studied by Dana, Berkeley, Goddard, and Cornell, and in the report which they publish they summarise in the form of a table the pathological and physiological effects attributed to the activities or disorders of the pituitary body and the pineal body. It seems that whereas tumours

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of the pituitary are associated with adiposity, sexual changes, genital atrophy, and infantilism, tumours of the pineal gland are associated with early development of the sexual organs and bodily functions, and early bodily and mental maturity.

The authors also report the feeding of animals and mentally defective children at Vineland. In respect to the latter investigation, they claim only a presentiment of a direct influence of the extract towards mental improvement, and conclude that "all such experiments are subject to so many disturbing factors that it seems necessary, in view of the slight gain recorded, that the experiment should be continued for a longer time.

### THE ADRENAL GLANDS.

One of the most important researches on the internal secretions of the ductless glands, of the many which we owe to the English physiologists, relates to the functions of the suprarenal glands. It has been known since the time of Addison that this gland is essential to life, and I need not tell you what is well known regarding the function of this gland in virtue of the adrenalin which it secretes, except in so far as it has been shown by Cannon and Elliott that the emotion of fear through the splanchnic nerve liberates adrenalin in excess into the blood. The whole story of the adrenal glands has recently been so admirably told in the Sydney Ringer Lecture, that I should recommend all who are interested in the functions of the ductless glands to read it. Still, in support of my thesis of the application of physiology to the study of mental processes, I cannot refrain from quoting one or two important generalisations from that lecture<sup>1</sup>:—

"Morphology, therefore, tells the same tale as physiological analysis. The adrenalin cells and the sympathetic nerves belong to a common system, whose first duty is that of sustaining the activities of the circulatory muscles. As the animal develops its muscular efficiency, learns a hundred new functions, and with a constant body temperature becomes independent of its environment, the sympathetic system becomes more and more complex and is split up into manifold possibilities of delicate adjustment. All these are but refinements of means for the one great end—to enable the animal to move more swiftly, to catch its prey and to fight. Fighting power rises with rise of the blood-pressure, reserves of sugar to feed the muscles are hurried up from the liver on the call of the circulating adrenalin, the daily routine of digestion is checked by intestinal inhibition, and the various segments of the bowel are cut off from one another by the closure of the sphincters. Cannon has reiterated this

<sup>1</sup> *Brit. Med. Journ.*, 1914, i, p. 1394.



view and, further, shows very neatly how the clotting of the blood by adrenalin which has been observed by myself and others is a further elaboration to check leakage in any chance wound of the body during action.

"By that curious antithesis of the emotions upon which Charles Darwin laid stress, the machinery employed to prepare for fight may, with the cowardice of civilization, be set as powerfully in motion only to express fright. And in this the adrenalin is equally, or perhaps even more, exhausted."

Our knowledge of the function of the cortex of the gland is still obscure. I have observed that in the systematic examination of the ductless glands the cortex has varied greatly in amount in different cases; and microscopic examination has shown, after staining with Scharlach, that the amount of lipoid has greatly varied. There is considerable evidence to show that the cortical cells of the adrenal gland, which are so largely developed in man as compared with the lower animals, are of great importance in the development of the body during its early period of existence, especially in respect to the development of the brain. It is also, as I have indicated previously, of great importance in relation to the development of the spermatozoa; and during pregnancy it increases in amount and provides doubtless a material necessary for the development of the growing embryo. The cholesterin esters are of extreme importance as constituents of the osmotic membranes of the blood corpuscles and the living cells of the body. The adrenal cortex was derived from a tissue which was once in close proximity to the early position of the sex glands in the abdomen. Adenoma of the cortex has been found associated with precocious development of the secondary sexual characters in males and females. But not only is there this mysterious correlation of the sex glands with the cortex of the adrenals, but there is also a correlation between the size of the brain and the development of the adrenal cortex in the animal series. The adrenal glands are invariably small in anencephalous monsters, as they are in brainless animals. The cortex of the adrenal is highly developed in the healthy human foetus; and all these facts support the argument that the cortical cells of the adrenal gland are a source of supply of the lecithin and cholesterin required for the enormous growth of the cerebral hemispheres in early life.

In the systematic investigation of the ductless glands which I have been making, in conjunction with Staff-Surgeon Kojima, I have been struck with the variability of the lipoid content, and one might have associated pathological conditions of the brain with its deficiency. Thus I recently made a post-mortem examination on a case of disseminated

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sclerosis, and I was quite surprised to find the small amount of lipoid present. Had I not known from Elliott's work that a few days' pneumonia would suffice to cause a great fall in the load of lipoid, one might have been tempted to correlate a connexion between disseminated islands of nervous tissue, in which the myelin had disappeared, with a deficient functional activity of the adrenal cortex. With all the difficulties and pitfalls that confront one in the application of physiology to the study of the mind in health and disease, bio-chemistry, which is still in its infancy, seems to me to promise the most hopeful results.

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**Microscopic Examination of the Central Nervous System in  
Three Cases of Spontaneous Hypothyroidism in relation  
to a Type of Insanity.**

By F. W. MOTT, M.D., F.R.S., Hon. LL.D.Edin.

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INTRODUCTION.

INCLUDED among the sixty female cases recorded in Dr. Kojima's detailed account of the condition of the ductless glands are three in which I have investigated the condition of the central nervous system, with a view to seeing if the microscopic changes are essentially similar to changes which I have previously described in conjunction with Dr. Brun, and published in the *Proceedings of the Royal Society of Medicine*, Section of Psychiatry, 1913, vi, pp. 75-100.

The three cases already recorded occurred in women of middle age, and the three I am about to refer to occurred also in women about the climacterium. The complete clinical notes of the cases are given by Dr. Kojima on pp. 38-50. An attempt will be made to correlate the psychic syndrome with the cortical changes observed in these cases.

MICROSCOPIC CHANGES IN THE CENTRAL NERVOUS SYSTEM.

The brains were hardened in formalin; sections of 5  $\mu$  were cut from blocks embedded in paraffin and stained by the Nissl method; other sections were stained by Ranke's Victorian blue method. Briefly stated, the changes observed were similar in character to those already described by Dr. Brun and myself.

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There is a universal chromatolytic change in the cells of the central nervous system, sparing no system or group of neurones entirely. The changes were very marked in the bulb, especially affected were the smaller cells of the autonomic nuclei—e.g., the vagus and glosso-pharyngeal. In the cerebellum the Purkinje cells show less chromatolysis than the large motor cells of the medulla oblongata, spinal cord and Betz cells, and there is no increase of the glia tissue (*vide* figs. 2, 5, and 6). These three asylum cases exhibited much more marked changes in the cells of the cortex than the two hospital cases previously described, and more than the asylum case McC., previously recorded. This latter case showed less pronounced mental symptoms than the three cases recently investigated, consequently it is not surprising to find that in the cortex of the cases now to be considered there were found more extensive cell changes of the cortex. An attempt will now be made to show a correlation of the mental symptoms with the changes found in the cortex. Unfortunately, the notes do not permit correlation of the changes in the bulb with the symptoms indicative of affection of the autonomic nuclei as in the hospital cases. Still, the main object of this communication is to show that there is a type of insanity occurring in women about the climacterium, in which a manic-depressive condition, associated with mental confusion, hallucinations, delusions mainly of persecution, loss of memory of recent events, and terminating in dementia, may arise as a result of a particular form of hypothyroidism. This hypothyroidism is characterised (1) by an atrophy of the glandular structure of the thyroid, interstitial fibrous hyperplasia and abundant infiltration of the same with lymphocytes; a condition of chronic inflammation arising from a toxic condition, probably local in its source, as the adjacent parathyroids show no such change. (2) By an increase in weight of the pituitary gland, and usually abundant colloid in the *pars intermedia*, which may be regarded as evidence of thyroid insufficiency. All four asylum cases of hypothyroidism in which the pituitary body was examined showed increased size of the pituitary and excess of colloid.

As a control it may be stated that the characteristic perinuclear chromatolysis of the nerve cells found in these four cases was not discovered in two cases of simple atrophy of the thyroid gland—viz., Case IV, and the male alluded to on p. 56. Examination of the thyroid gland in these two cases showed still normal colloidal vesicles, and vesicles filled with epithelium or degenerated epithelium; and although there was an increase of the interstitial fibrous tissue, there was no

lymphocytic infiltration indicative of a local toxic inflammation; neither was there any increase of weight of the pituitary, nor excess of colloid observed in section of this gland.

It is permissible, therefore, to correlate the changes in the nervous system with this particular form of hypothyroidism, in which the gland, as in Case I, has undergone a pseudo-hypertrophy, or Cases II and III, in which the gland is considerably below the average weight. The increase of colloid in the pituitary may be regarded as an index of the extreme degree of hypothyroidism, but further observations are required

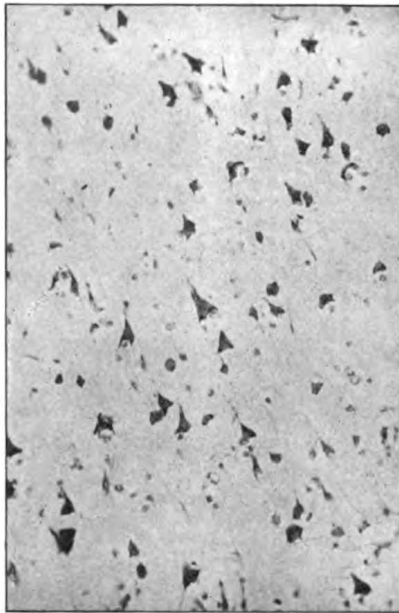


FIG. 1.

Section of motor cortex pyramidal layer. ( $\times 200$ .)

to settle this point. If the conclusion of Hering and Cushing be accepted, that the colloid of the pituitary (*pars intermedia*) passes into the cerebrospinal fluid, then this excess may produce a functional disturbance of the nerve cells, or, as seems more probable, the thyroid insufficiency may be directly correlated with the deficiency of the basophile substance of the nerve cells. In the case of McK., previously described, Brun and I showed that the small posterior spinal ganglion cells were especially affected as well as those of the central nervous system. In any future case that I may have the opportunity of examining I shall examine the sympathetic ganglia.

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EXAMINATION OF THE CORTEX CEREBRI OF CASE I, STAINED  
BY NISSL METHOD.

All the cells of the pyramidal layer under a low power show a deficient basophile staining; the cells are stained a pale blue. Obviously

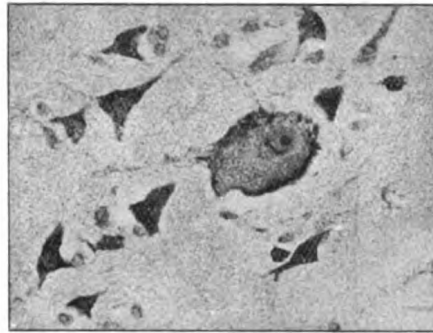


FIG. 2.

Betz cell of motor cortex. ( $\times 300$ .)

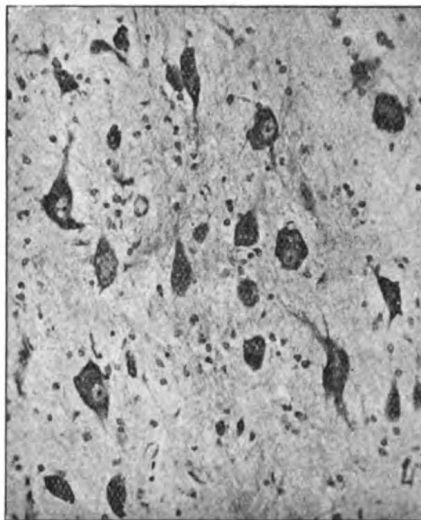


FIG. 3.

Eighth nucleus: A group of cells less affected than is usually the case, but some have an eccentric nucleus and some perinuclear chromatolysis. ( $\times 250$ .)

the stain is paler in all the cells around the nucleus—perinuclear chromatolysis. Many seem to have lost their apical processes, and no longer retain their pyramidal shape (*vide* fig. 1). There is still

evidence of the existence of the columns of Meynert. Examination with an oil-immersion lens does not show a single normal cell. There is an obvious deficiency of basophile staining, especially around the nucleus; the edges of the cells are ragged; in many the processes are broken off. There are no Nissl blocks, only a basophile staining dust seen generally at the periphery of the cell. The nucleolus is stained deeply; the nuclear membrane and nuclear substance are almost invisible, or only faintly visible and capable of differentiation from the rest of the

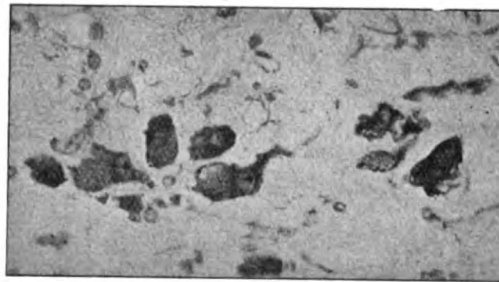


FIG. 4.

A few cells of the eleventh nucleus close to the median raphe. ( $\times 250$ .)



FIG. 5.

Betz cell of motor cortex (Case II) showing eccentric nucleus. Absence of Nissl granules and processes broken off. Three pyramidal cells are also seen; two exhibit marked perinuclear chromatolysis, one is surrounded by satellite cells. ( $\times 450$ .)

cells in a large proportion of those examined. In a large number of the cells there are scattered through the cytoplasm very fine pale yellow round granules, surrounded by uniform pale blue-stained substance. These are lipochrome granules; they are stained by Scharlach, and the great majority of the cells contain some in great or less quantity. These pigmented granules are found in the cells of all old people and

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are not of much significance in the special pathological condition under consideration.

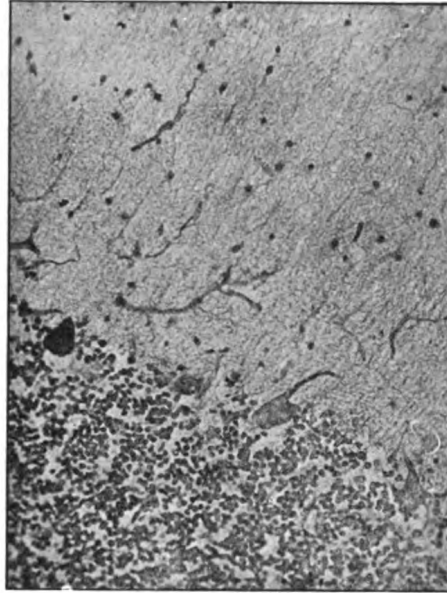


FIG. 6.

Section of the cerebellum stained by Ranke's Victorian blue method for neuroglia. The Purkinje cells are deeply stained, and there is no excess of glia tissue. Compare this with fig. 10. ( $\times 250$ .)

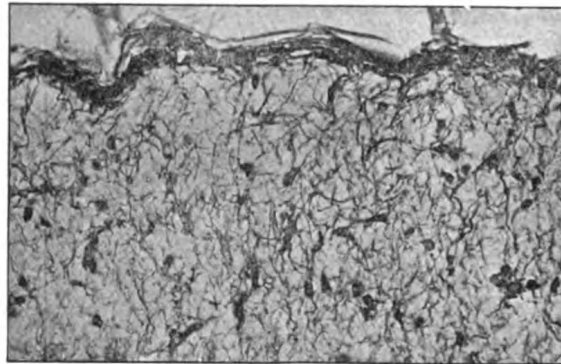


FIG. 7.

Section of superficial layer of motor cortex stained by Ranke's method. Some excess of glia tissue is seen. ( $\times 250$ .)

The changes above noted are just as marked in the deeper layer of polymorphic cells of the cortex as in the pyramidal layers. Some of



the largest pyramids and some of the Betz cells show still some basophile substance, taking the form of an imperfect Nissl granulation pattern at the periphery of the cell and on the processes (*vide* fig. 2).

*Medulla Oblongata*.—Every cell in the section, including those of the olive, shows some degree of chromatolysis; the great majority of cells show an advanced perinuclear chromatolysis, the Nissl granules being replaced by a fine basophile staining dust. A few of the large cells of the somatic motor nuclei have a Nissl pattern, but even these show perinuclear disappearance of the granules. The cells of the various nuclei are not equally affected. Thus the eighth nucleus shows cells exhibiting less perinuclear chromatolysis than others (*vide*

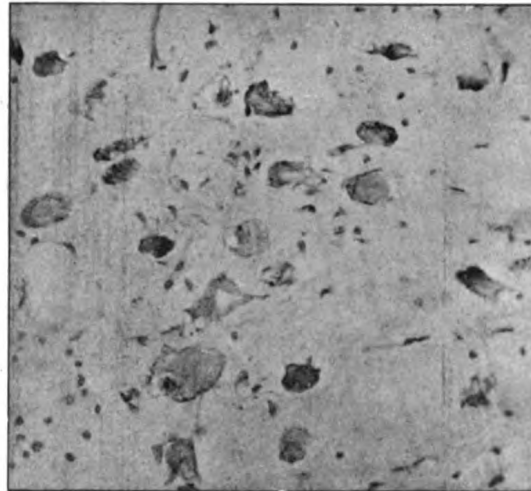


FIG. 8.

Roller's nucleus: Medulla oblongata showing advanced chromatolysis of the cells. ( $\times 250$ .)

fig. 3). The smaller cells show, as a rule, the greater chromatolytic change. They are often with ragged edges, or the processes are broken off (*vide* fig. 4). Still, as in the cases previously described, the bio-chemical change is a general one affecting the whole of the neurones of the central nervous system.

The other two cases (II and III) show the same general perinuclear chromatolysis. Although there does not appear to be an actual deficiency in number of the cortical cells, yet microscopic examination with an oil-immersion lens shows that none of the cells can be regarded as of normal appearance, either in the medulla oblongata or the cortex,

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but they are by no means all equally affected. As a rule the small cells of the cortex show more change, but this may be due to the fact that they normally contain less basophile substance. Still, examination of the large Betz cells (*vide* fig. 5) shows a striking contrast to the cells of Purkinje (*vide* fig. 6). Many cells of the cortex and of the medulla show dendrons or dendrites broken off. The nucleus is eccentric and the basophile substance has almost disappeared in many of the cells. The satellite cells have greatly increased around these decaying neurones (*vide* fig. 5). The cortex, stained by Ranke's Victorian blue method, shows that where the nerve cells of the cortex are most affected there is an increase of neuroglia tissue; this glia hyperplasia

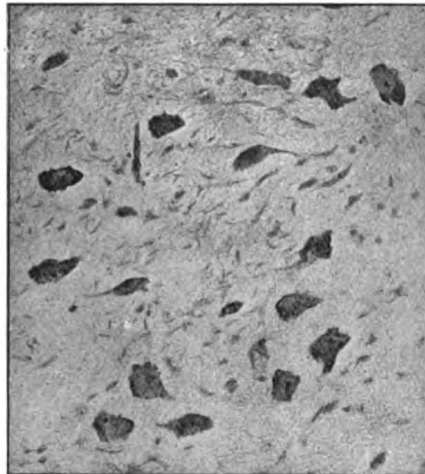


FIG 9.

Cells of nucleus ambiguus showing perinuclear chromatolysis. ( $\times 250$ .)

is not equally distributed, and is most obvious in the tangential layer of the cortex (*vide* fig. 7). In Case II there is apparently hyperchromatosis of the cells of the olive, whereas other groups of small cells, such as those of the vagus and glosso-pharyngeal nuclei, show a very marked chromatolysis. Sections stained by the Heidenhain hæmatoxylin method show a large number of cells stained pink instead of blue. These are the cells which by the Nissl method show a marked chromatolysis.

In Case II groups of neurones in the medulla oblongata show very marked chromatolytic changes, and many cells appear to have their processes broken off (*vide* figs. 8 and 9). Sections stained with Victorian

blue show an apparent increase of the glia tissue around these cells (*vide* fig. 10). The medulla and cortex of this were also stained by the Bielchowsky silver method. It appeared that the superior layer of small pyramids and the large Betz cells presented the greatest degree of fibrillary change. Many of the cells of the superior pyramidal layer had entirely lost their pyramidal shape. Still, a very marked contrast exists between the appearances presented by the cortical layer of cells in hypothyroidism and general paralysis or organic dementia (*vide* fig. 11). This leads one to think that the symptoms are largely due to

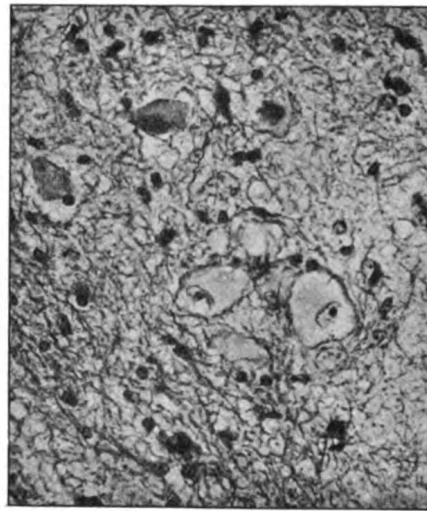


FIG. 10.

Group of cells of medulla oblongata stained by Ranke's Victorian blue method. Most of the ganglion cells are unstained except the nucleolus; the glia cells and glia fibril network show hyperplasia. Glia proliferation, however, is exceptional. ( $\times 300$ .)

a lack of functional energy which may be correlated with the marked disappearance of the Nissl substance (kinetoplasm), possibly associated with a toxic condition.

#### SIGNIFICANCE OF THE NISSL GRANULES AND CHROMATOLYSIS IN HYPOTHYROIDISM.

The perinuclear chromatolysis found in hypothyroidism is not specific, it is met with in other toxic conditions—e.g., lead encephalitis and alcoholic psychosis, and similar changes may be seen in experimental

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anæmia and following sections of the axis cylinder of a nerve cell. The Nissl granules of basophile substance, as I pointed out in 1900 (the Croonian Lectures, "On the Degeneration of the Neurone"), probably represent kinetoplasm, but in the living cell this kinetoplasm does not take the shape of granules forming a pattern in the cell. Nevertheless, the amount of this basophile staining substance in the form of Nissl granules may be regarded as evidence of the amount of energy substance (neuro-potential) which the cells possessed during life. In the healthy cell it is continually undergoing disintegration and

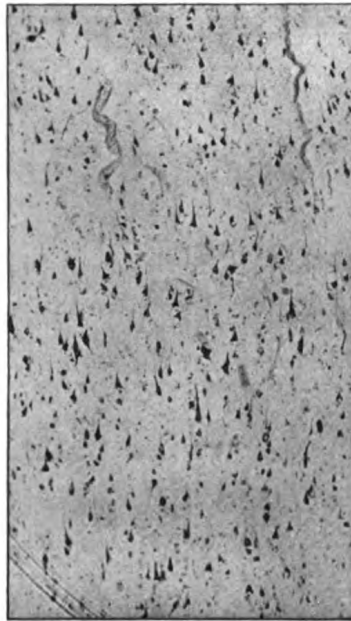


FIG. 11.

Section of cortical pyramidal layer (Case III). There are no signs of increased vascularity or diminution in the number of ganglion cells, nor is there any evidence of replacement of neural tissue by glia tissue as is the case in organic dementia or general paralysis. ( $\times 85$ .)

automatic re-integration. When the cell is damaged by injury of its processes, as, for example, section of the axon, experimental anæmia, toxic conditions of the blood, or hypothyroidism, metabolic equilibrium is no longer maintained; its osmotic surface tension is altered and water passes into the cell, causing it to swell, displacing the nucleus and causing a chromatolytic appearance. The disappearance or partial disappearance of the kinetoplasm in the autonomic nuclei of the bulb,

Dr. Brun and I correlated with cardiac and other bulbar symptoms which were observed in the two hospital cases and one asylum case that we recorded. The chromatolysis of the somatic cells may also be correlated with the slowness of utterance so characteristic of myx-œdema. The marked chromatolytic changes which were observed in the cortex of the four asylum cases may be correlated with the mental confusion noted in these cases.

#### THE LIVING NERVE CELL AND CHROMATOLYSIS.

This basophile-staining substance which forms the Nissl granules does not exist as such in the living cells. If living cells are examined with the dark-ground microscope they are seen to be filled with small granules or globules, each of which after escaping from the cell remains discrete. They are refractile, and therefore appear bright white; this is due to a delicate covering film of a lipoid substance which encloses a colloidal fluid probably consisting of a solution of salts and cell globulin (*vide* fig. 12). When the cell dies this colloidal fluid is coagulated and the precipitated proteid substance is massed together into little blocks—the Nissl granules. The film that covers each globule is stained by vital methylene blue, and a living cell stained by vital blue represents the appearance of an emulsion of minute faint blue globules. If the living cell thus stained be kept in an atmosphere of nitrogen the stored oxygen is used up and a leuco-base is formed, causing the globules to lose their colour, the cell being then stained a faint green. On admission of oxygen, the living cell again becomes blue. It thus appears that we have a large oxygen surface, like spongy platinum, within the osmotic membrane of the cell. When the cells die, the lipoid film of the globulin-containing fluid is destroyed, coagulation occurs and the Nissl granules are formed. Examination of living cells of the spinal ganglia and spinal cord of animals in which the sciatic nerve has been cut shows that the cells have imbibed water. The refractile granules are not so densely packed, they seem to be pushed aside, and the nucleus becomes eccentric in position. It would be interesting to see what is the condition of the living nerve cells in experimental hypothyroidism, as we should then be able to see whether a similar condition occurs as is produced by section of the axon. The chromatolysis observed in hypothyroidism may be explained by a toxic condition of the blood altering the osmotic membrane of the nerve cells, and thus leading to imbibition of water; or it may be

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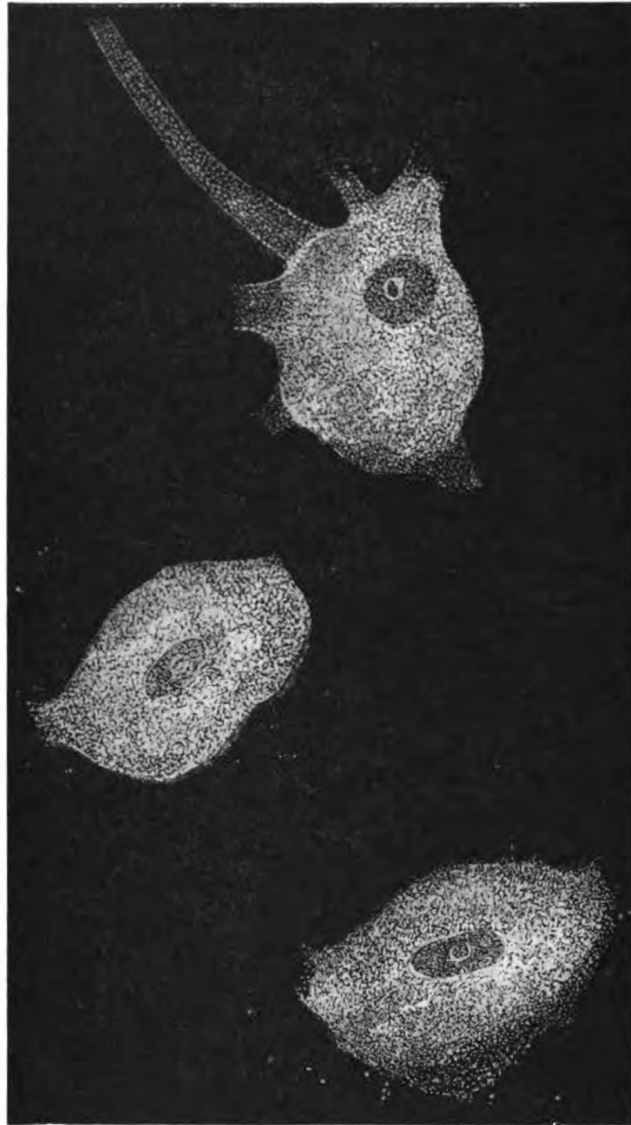


FIG. 12.

Drawing of an anterior horn cell (uppermost) with processes and two posterior spinal ganglion cells as seen by dark-ground illumination while still in the living state. (Obj. 4 mm., apochrom. oc. 4.)

explained by the absence in the blood of thyro-iodine, or some substance essential for nerve cell metabolism. Probably both factors are a causative agency, but the absence of the gland secretion is the essential factor, because it is certain that the characteristic mental and physical symptoms and signs may greatly improve by treatment with administration of thyroid gland. The work of Edmunds, carried out in my laboratory, shows that thyro-parathyroidectomy causes a chromatolysis of the nerve cells in dogs; his work also shows the importance of lime salts in prolonging the life of the animals.<sup>1</sup>

Asylum cases frequently show but slight physical signs of myx-œdema, although the mental symptoms are marked, which affords an explanation as to why these cases have been erroneously diagnosed as alcoholic psychosis and dementia paralytica; consequently they have not been treated with the only drug that can do good. Cases should not be mistaken for general paralysis of the insane, for this disease can now always be diagnosed by the examination of the cerebrospinal fluid—an absence of lymphocytes and of a positive Wassermann reaction absolutely excludes general paralysis.

I have myself seen a case of agitated melancholia, or as it is often termed “manic-depressive insanity,” and heard of several cases, with few physical indications of hypothyroidism, which occurred in women about the climacterium, deriving great benefit from administration of thyroid gland. If my observations are correct, the treatment must not be delayed until destructive neuronc changes and substitutive glia hyperplasia have occurred. Whether we regard the mental syndrome as a consequence of a toxic condition or of a sub-minimal deficiency of an essential substance, or of the two combined, the fact remains that there is at the climacterium in women a group of mental symptoms associated with definite changes in the central nervous system and hypothyroidism.

<sup>1</sup> “The Changes in the Central Nervous System resulting from Thyro-parathyroidectomy,” *Proc. Roy. Soc. Med.*, 1912, v (Neur. Sect.), p. 179.





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## Section of Pathology.

President—Dr. F. W. ANDREWES, F.R.S.

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(February 13, 1917.)

### The Changes in the Central Nervous System in Hypothyroidism.

By F. W. MOTT, Major R.A.M.C., M.D., LL.D., F.R.S.

I HAVE published two communications in the *Proceedings* of the Section of Psychiatry of this Society on the changes in the central nervous system in hypothyroidism. The nervous symptoms of myxœdema point to a condition of exhaustion of nervous energy, which can be remedied by the administration of thyroid gland; consequently *a priori* upon the assumption that the basophile substance of the nerve cell is a source of nervous energy, we should expect to find what actually I have now found to exist in seven cases—viz., a marked chromatolysis, which in sections of the brain and spinal cord is revealed by the partial or complete disappearance of the Nissl granules throughout the central nervous system.

Since the former publications, a very advanced case of hypothyroidism was admitted to Claybury Asylum: this patient showed well marked signs of myxœdema and very marked mental nervous symptoms. Before recounting the clinical notes and pathological findings in this case, which accord in great measure with the other cases recorded, except that the mental symptoms were more profound, I will briefly relate a summary of the clinical facts and pathological findings in the six previously recorded cases. But before doing so, I should like to call attention to a valuable paper by Dr. Kojima on the

## 2 Mott: *Central Nervous System in Hypothyroidism*

"ductless glands in 110 cases of insanity." This work was done in my laboratory, and published in the *Proceedings* of the Section of Psychiatry of the Royal Society of Medicine (vol. viii). I shall have occasion to refer to one or two conclusions at which Dr. Kojima arrived in connexion with hypothyroidism and the other ductless glands.

### CONCLUSIONS REGARDING A CORRELATION OF HYPOTHYROIDISM AND CHANGES IN THE CENTRAL NERVOUS SYSTEM.

There is a universal chromatolytic change in the cells of the central nervous system, sparing no system or group of systems of neurones entirely. The changes have been especially noted in the smaller cells of the autonomic nuclei—e.g., the vagus and glosso-pharyngeal. The cells of the olivary body show much less change, and the Purkinje cells of the cerebellum show less chromatolysis than the large motor cells of the medulla oblongata, spinal cord and Betz cells of the cortex, and there is no increase of neuroglia. All the asylum cases, especially four of the five, showed marked chromatolysis of the cortical cells. The one that showed the least degree of mental confusion and other signs of insanity, exhibited the least change in the cortical cells.

The lantern slides of the case I am about to show exhibit very marked changes, and the mental symptoms in this case were most pronounced. Unfortunately, the notes do not permit correlation of the changes in the bulb, in these asylum cases, with the symptoms indicative of affection of the autonomic nuclei, as was possible in the hospital cases.

But I have come to the conclusion that there is a type of insanity in women about the climacteric, in which a manic-depressive condition, associated with mental confusion, hallucinations, delusions—mainly of persecution—loss of memory of recent events, slowness of thought and utterance, and terminating in dementia, may arise as a result of a particular form of hypothyroidism. This hypothyroidism is characterized:—

(1) By an atrophy of the glandular structure of the thyroid, interstitial fibrous hyperplasia, and abundant infiltration of the same with lymphocytes; a condition of chronic inflammation arising from a toxic condition, probably local in its source, as Kojima has shown; the adjacent parathyroids do not exhibit this change.

(2) By an increase in weight of the pituitary gland as a rule, but not always; nevertheless, there is, as was shown by Boyce and Beadles

long ago, and later by Herring in experimental hypothyroidism, an increase of the *pars intermedia*. Herring has also shown that the cells of this structure invade the *pars nervosa*, and I shall show that this has occurred in the case under consideration. This is of interest, for Schäfer, in his work "The Endocrine Organs," states: "Whether the phenomenon also occurs in myxœdema has not been noted, but it will probably be found to be the case." All five cases of hypothyroidism, in which the pituitary was examined, showed an excess of colloid in the *pars intermedia*. As a control it may be stated, that the characteristic perinuclear chromatolysis of the nerve cells found in these cases was not discovered in two cases of simple atrophy of the thyroid gland. Examination of the thyroid gland in these two cases showed still normal colloid vesicles, and although there was an increase of fibrous tissue, there was no lymphocytic infiltration, indicative of a local toxic inflammation; neither was there any increase of the *pars intermedia* or colloid material, observed by Dr. Kojima.

Of course we have always to consider how far the atrophy of a gland, and failure of its function, may act in upsetting the bio-chemical balance existing between the secretions of all the ductless glands and the sexual glands. In the five asylum cases in which the suprarenal glands were examined a deficiency of lipoid in the cortex was observed, but it would be unscientific to correlate this condition certainly with the thyroid atrophy, for the patients have died usually of some acute infective disease, and Elliot has shown that the lipoid is diminished in cases of death from infective disease. Still it is suggestive. Dr. Kojima, in his exhaustive examination of all the ductless glands in three cases, came to the conclusion that he could exclude the probability that changes in any other ductless glands than the thyroid can be responsible for the nervous and mental symptoms, and the histological changes in the central nervous system. It is suggested, however, that the ovaries were affected in three cases. "It may be remarked that these were the cases in which there was not merely a glandular atrophy, but there was also a marked chronic inflammatory, interstitial change."

This case, which I am about to show, had extraordinarily large ovaries and an enormous number of corpora albicantia, but healthy Graafian follicles were present.

It may be mentioned that in all these cases the blood and cerebro-spinal fluid gave a negative Wassermann reaction.

## A CASE OF MYXŒDEMA.

E. A., aged 38. Admitted to Claybury Asylum on March 23, 1916, with no history of previous illness or treatment. The medical certificate states: "She is continually shouting and screaming out that she is falling."

*Physical Examination.*—Bruises were found on forearms and legs. The muscular system showed paresis. The abdomen was distended, and the lungs full of râles. There was incontinence of urine, and continuous metrorrhagia. The knee-jerks were absent, but the patient's condition did not permit of systematic examination of the reflexes, as she was in the last stage of exhaustion when admitted."

*Abstract of Notes made on Admission.*—"Patient was suffering from confusional insanity with myxœdema. She was at times very noisy, due to hallucinations of sight and hearing. She rambled inconsequently of things she imagined she saw and heard. She thought she was falling through space and was inclined to be noisy. She took nourishment—milk and brandy and beef-tea, but her breathing became laboured, and her face and hands blue. Her pulse was barely perceptible, and temperature subnormal. General weakness and restlessness developed with the onset of broncho-pneumonia. She died from heart failure about thirty-eight hours after admission."

*Notes of Post-mortem Examination.*—"Examination of the brain showed considerable wasting of the convolutions, with enlarged sulci, especially in the central region; the cortex was thin and the striation poor; the fourth ventricle was not granular, and the membranes stripped without erosion. The weight of the brain was 1,115 grm., the right hemisphere weighing 480 grm. and the left 475 grm. The dura mater was slightly thickened, and there was excess of fluid in the subdural space. The pia-arachnoid was slightly opaque but not adherent. There was slight atheroma of the vessels. The thyroid was very small and atrophic. The bronchial glands were enlarged and black, and the lungs congested and filled with muco-purulent material, and showed signs of commencing broncho-pneumonia; there was adhesion of the posterior border and base of the left pleura. The right lung weighed 655 grm. and the left 610 grm. The heart was well shaped, with a marked deposit of fat; the right ventricle enlarged, as also the auricle, and there was slight atheroma of the aorta and great vessels. The liver weighed 1,470 grm., and was enlarged, with increase of fibrous tissue, and opacity of the capsule in some places. The bile was dark, and the

spleen weighed 145 grm. The kidneys each weighed 160 grm.; they stripped easily, were slightly atrophic, with a fatty deposit everywhere. The adrenals were small, but of normal appearance on section. The uterus was long and in good condition, but the ovaries were unusually large and abnormally long: as long as the tubes. The right ovary weighed 7 grm. and was 3 in. long; the left ovary weighed 5.5 grm. and was 2½ in. long. The patient weighed 68 kilos; her hair was very thin, and her general condition fatty. The muscular system was covered with a fatty deposit, and her teeth were bad. The cause of death was heart failure."

*Remarks.*—The practitioner under whose care the patient had been told me that he had considered the case was one of general paralysis of the insane. She was demented, and her speech was affected. Seeing that he had had experience as a medical officer at an asylum he was surprised when I told him that the brain presented no macroscopic or microscopic signs of this disease, and that the case was one of myxoedema with confusional insanity.

#### *Microscopic Examination.*

Portions of the ascending frontal cortex, the basal ganglia, the pons and medulla, after hardening in formaldehyde solution, were prepared for sections by the paraffin method. Also the pituitary, thyroid and suprarenal glands were similarly treated.

Sections of the brain, 5 c.c. thick, were cut and stained by Nissl's method, also with polychrome and thionin dyes. A very distinct chromatolysis of the cells in all the regions was observed; especially marked was the change in the Betz cells of the cortex, although all the pyramidal cells are more or less affected. Some cells have lost all their basophile staining substance; in others there is a marked perivascular chromatolysis and a complete or partial disappearance of the granules. The nucleus is often eccentric in position (*vide* photomicrographs, figs. 1 and 2).

The cells of the medulla, the pons and the basal ganglia, show a similar marked chromatolysis (*vide* photomicrograph, fig. 3). The changes correspond indeed with those I have previously described as occurring in myxoedema, only they are, generally speaking, more advanced; especially do I refer to the cells of the cortex.

Sections of the *thyroid* were cut and stained with hæmatoxylin and eosin. The characteristic appearance observed in the other cases was

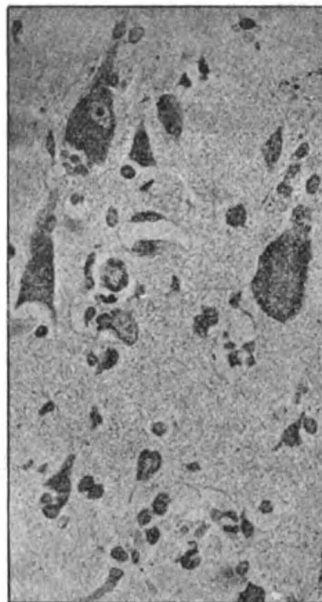


FIG. 1.

Section of frontal cortex, stained by Nissl's method. The small, medium, and large sized pyramidal cells all show advanced chromatolysis. ( $\times 480$ .)

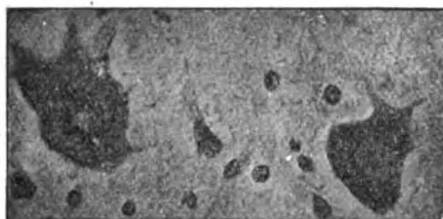


FIG. 2.

Section of ascending frontal convolution, stained by Nissl's method. Two large Betz (psychomotor) cells exhibiting advanced chromatolysis. No tigroid substance can be seen. ( $\times 390$ .)

demonstrable—namely, almost complete disappearance of the colloid in the vesicles, a marked interstitial fibrosis and lymphocyte infiltration.

*The Pituitary Gland.*—Sections were cut and stained with hæmatoxylin and eosin, and microscopic examination showed that the *pars intermedia* exhibited an excess of colloid, and an extension of this portion of the gland into the *pars nervosa* to such a degree that outlying isolated cells were observed almost throughout the whole posterior portion of the gland. The examination of the vesicles of the *pars intermedia* with a high power magnification shows that the colloid substance is a secretion of the cells, for their cytoplasm can be seen filled with a hyaline eosin oxyphile colloid staining substance, similar to

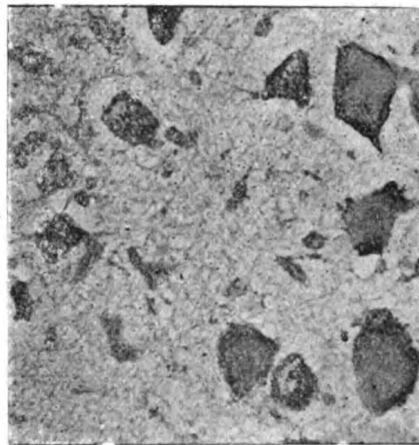


FIG. 3.

Small and large cells of the hypoglossal nucleus showing advanced chromatolysis. ( $\times 340$ .)

the oxyphile colloid in the vesicles. The most outlying cells in the *pars nervosa* also show this hyaline eosin staining substance, *vide* fig. 4. I have not found "an increase of free hyaline and granular masses" through the *pars nervosa*, described and figured by Herring, as occurring after removal of the thyroids, but the conditions above noted are of a similar nature though less in degree. What part this increase of the colloid of the *pars intermedia* may play in accounting for the clinical and anatomical changes in the nervous system, it is not permissible to say on existing evidence. It might be argued that it is a compensatory change; Schäfer, however, states "the pituitary colloid

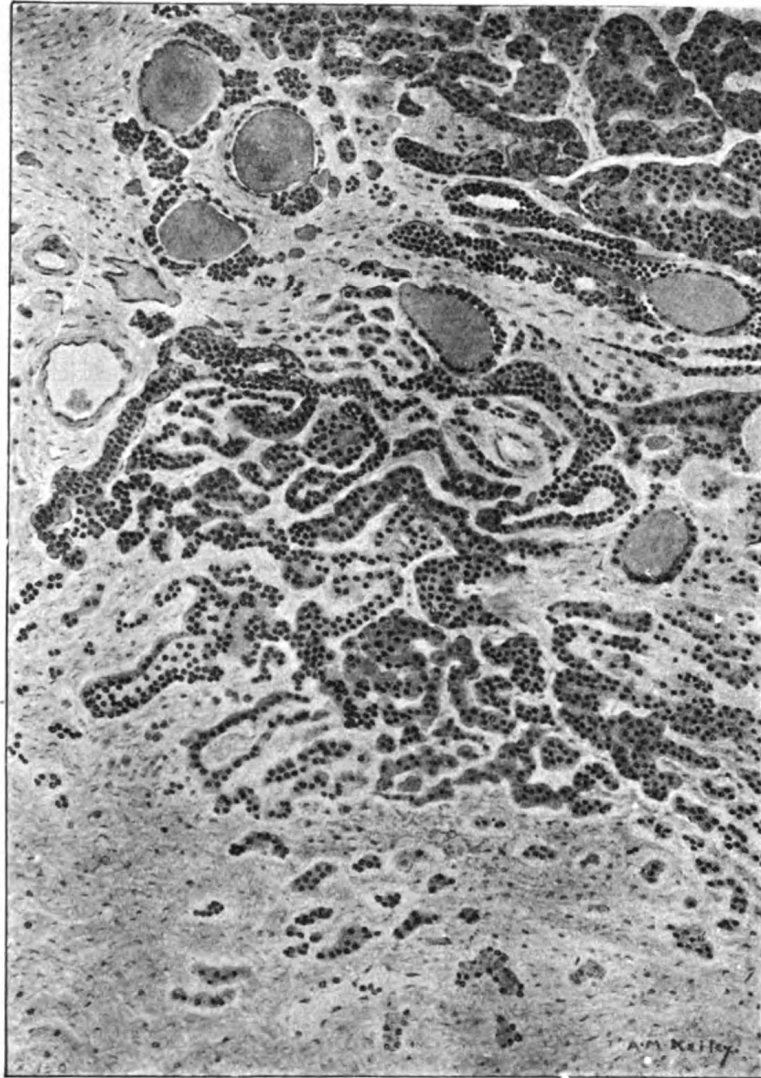


FIG. 4.

Drawing of the *pars intermedia*, showing the colloid in excess, extension of the gland structure into the *pars nervosa*, and outlying isolated cells scattered through the whole of the adjacent posterior lobe. ( $\times 100$ .)



is not identical with that of the thyroid. It is noteworthy that it does not contain iodine, which is a characteristic component of the thyroïdal colloid in all animals. Even many months after thyroid removal, Sutherland Simpson and Andrew Hunter were unable to detect the least trace of iodine in the sheep's pituitary. The pituitary cannot take the place of the thyroid in animals affected with cachexia thyreopriva, nor is pituitary extract able to take the place of thyroid extract in the treatment of goitre and myxœdema. There is therefore no evidence that these two organs act vicariously." However it seems that, as Cushing and Herring have shown that the colloid of the *pars intermedia* passes into the third ventricle, it therefore enters the cerebrospinal fluid, and in this way it may have some influence in determining the nervous symptoms and the chromatolytic changes on the nerve cells. The physiological activity of the posterior lobe of the pituitary gland is connected with the presence in it of the colloid secretions of the *pars intermedia*, for it is difficult to believe that the neuroglial tissue, of which the posterior lobe consists, can possess active autacoid properties.

*The Suprarenal Glands.*—Sections were cut by freezing formaldehyde hardened portions of the gland; these were then stained with Scharlach and hæmatoxylin, and mounted in Farrant's solution. These showed marked diminution of the lipoid contents of the cortex, more so than I think can be accounted for by the broncho-pneumonia found post mortem. The *ovaries* were extraordinarily large, contained a great number of corpora lutea vera, and numbers of normal Graafian follicles, pointing to a high degree of reproductive activity; whether this evidence of generative hyperfunction can be associated with the changes in the thyroid gland I am unable to say, but it is well known that an important interaction exists between the thyroid and the generative glands. The thyroid becomes enlarged at puberty, during menstruation and during pregnancy. Myxœdema is much more frequently met with in women than in men.



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## Histological Examination of the Ovaries in Mental Disease.

By the late LAURA FORSTER, L.R.C.P. & S.Edin., M.D.Berne.<sup>1</sup>

(Communicated by F. W. MOTT, Major R.A.M.C.(T.), M.D., F.R.S.)

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THE following paper is the result of an investigation of human ovaries, carried out in the Pathological Laboratory, Claybury Asylum. The work was suggested to me by Dr. F. W. Mott, who considered that a systematic examination of the ovaries in cases of mental disease would be of medical and social importance.

There are two periods of life in the female, when the onset of insanity especially occurs—viz., early adolescence and the involutional period. This has been very clearly shown by Dr. Mott in a collective investigation of over 4,000 related cases, who are at present in, or who have been discharged from, or who have died in the London County Asylums. The parents of these insane offspring, in nearly 50 per cent. of the cases affected, have their first attack during the involution period from 45-60. Furthermore, Dr. Mott has found certain types of mental degeneration associated with absence of ova in the glands; others with absence of signs of maturation in the ova, both indications of sterility; he considers the latter is further evidence of "anticipation," by which the children of insane parents are affected at a much earlier

<sup>1</sup> From the Pathological Laboratory of the London County Council Asylums.

age than the parents, and in a more intense form. This may be a way in which nature tends to end, if it cannot mend, a degenerate stock.

As evidence of the correlation of brain and sexual glands, Ceni's experiments on birds are important. He removed one hemisphere, and the birds surviving the traumatic shock were killed after periods varying from a few months to three years, and their ovaries were subsequently examined histologically. The primary shock had the effect of causing them to cease laying eggs for some months. In the following year they began to lay again, but in the second year few eggs were laid, or they ceased altogether from laying. The birds were otherwise in a healthy condition. The examination of the ovaries showed premature progressive involution. The writer considers that the changes in the ovaries are an expression of a permanent state of functional torpor of the organ, in consequence of which ovulation is more limited than under normal conditions, and finally becomes entirely arrested. The arrest of this function causes a rapid and progressive involution, which affects the whole parenchyma of the ovary, and may be taken as a premature dynamic exhaustion of the sexual gland. The conclusions drawn are that there are very intimate dynamic relations between the brain and the ovary, the function of the latter being directly dependent on the anatomical and functional integrity of the brain. The writer considers that these facts have an important bearing on the question of reproduction in the physically unfit.

The ovary has of late received rather a prominent place as an important secreting gland. I refer my readers to Biedl's exhaustive work on internal secretion, where a very full list may be found of all the writers who have studied this question anatomically and physiologically. The parts of the ovary credited with the function of secretion are the corpus luteum and the atretic follicle. Limon made a comparative histological study of the ovaries of various animals, and states that the tissue arising out of the atretic follicle, through proliferation of the theca interna, consists of cells of epithelioid form, and he gives it the name of "glande interstitielle de l'ovaire." He has found these epithelioid cells in numerous groups imbedded in the stroma of certain animals. Fraenkel likewise made a detailed examination of the ovaries of animals, and also of human ones. He found these epithelioid cells in numbers in the ovaries of certain animals, more especially the rodents, but they were entirely absent in the anthropoids and man. He

concludes, therefore, that this tissue cannot be responsible for a large, general and important function.

Dr. Mott kindly supplied me with all the material available at the Pathological Laboratory, Claybury, and also sent me some from Charing Cross Hospital. For the rest, I am indebted to Dr. Turnbull, Director of the Pathological Institute, London Hospital, and to the following Medical Superintendents of the London County Asylums: Dr. Ogilvy, of Long Grove; Dr. Baily, of Hanwell; Dr. Gilfillan, of Colney Hatch; Dr. Stansfield, of Bexley; Dr. Lord, of Horton; Dr. Donaldson, of the Manor Asylum; Sir James Moody, of Canehill; and to Dr. Elkins, of Leavesden; and Dr. Campbell, of Caterham.

The ovaries were taken from 100 cases of persons who had died in the London County Asylums, and included cases diagnosed as dementia præcox, mania, melancholia, general paralysis of the insane, epilepsy and imbecility. To control the above cases, ovaries were taken from women and children who had died in the London and Charing Cross Hospitals. The control ovaries cannot, however, be considered as entirely satisfactory, as many of them were taken from persons who had died from a long-standing disease. For instance, those belonging to a woman, aged 32, with chronic interstitial nephritis, showed complete involution.

#### METHODS.

The ovaries were fixed in Müller's fluid, and then taken through various strengths of alcohol. A certain number were embedded in paraffin, but for the majority celloidin was used, as it causes less shrinkage. The blocks were cut into serial sections, and in cases where the Graafian follicles were scanty in number, the whole of the ovary was cut through in this manner. In other cases it was considered sufficient to cut a series of one block only. The majority of sections were stained after cutting with hæmatoxylin and eosin. A certain number of blocks were stained by the alum-carmin method before cutting, and afterwards counter-stained with eosin.

#### HISTOLOGY OF THE NORMAL HUMAN OVARY.

The stroma of the human ovary consists essentially of a dense network of fibrous bands, interspersed in places by smooth muscle-fibres, and through which blood-vessels run. In the stroma are embedded the Graafian follicles (figs. 4 and 5, pp. 16, 17), each of which consists of

a layer of epithelium, bounded on its outer edge by a basement membrane. Lying within the follicle is the ovum, surrounded by its zona pellucida. As the follicle increases in size the epithelial layers become multiplied, and at a certain stage of development the discus proligerus is formed. This is a thickening of the epithelium at one end of the follicle, in which the ovum can be seen embedded (fig. 8, p. 18). The Graafian follicles vary considerably in number according to the age of the individual. In the new-born and quite young person the larger part of the stroma consists of follicles, but as age advances, and the follicles diminish in number, either by rupture or atresia, their place is filled by the so-called corpora lutea, which, in their turn disappearing, give way to fibrous tissue. I have not observed in the human ovary those groups of epithelioid cells noticed by Heape in abundance in the rabbit, and by Limon in the rabbit and rodents. I noticed two principal forms of corpus luteum which occur in varying numbers throughout the stroma, the size of which varies considerably. The first I have not been able to follow in its development, and have only noticed it in one phase, where it consists of a nodule of non-cellular protoplasm (which takes a deep eosin stain) separated off into columns by thin trabeculae of connective tissue, which converge to a central strand, forming the axis of the nodule. I believe this is the form which follows the rupture of a follicle (fig. 6, p. 17). The second form is the one taking the place of the follicle which undergoes atresia. It consists of a nodule of loosely arranged connective tissue, separated off by delicate bands of denser connective tissue. I have noticed a number of these in process of formation round a degenerating ovum which has lost its surrounding membrana granulosa (figs. 1, 2 and 3, pp. 15, 16). The zona pellucida often remains intact after the nucleus has lost its power of staining, and the plasma is shrunken.

These two forms of corpus luteum are quite different in appearance, and according to Paladin and Beigel's acceptance of the terms, I have called the former "corpus luteum verum," and the latter "corpus luteum spurium." The name of corpus luteum verum is attached by some authors to that form only which occurs when pregnancy takes place. However, as the difference between those occurring with or without pregnancy seems to be only a question of size, the designation does not seem to me justified, and as Lawson Tait says, "the belief that there is such a thing as a true corpus luteum in relation to pregnancy is one of the most extraordinary crazes that has crept into medical belief."

## RESULTS OF THE HISTOLOGICAL EXAMINATION.

As it was impossible in so large a number of cases to estimate the absolute number of follicles present in each ovary, I adopted as a method of comparison the plan of counting the largest number present at any one level throughout the sections examined. I append here a tabulated statement of each case, with the results summarized, and give below a summary of comparative results according to age and mental disease.

*Dementia Præcox.*—In this group the ovaries of all those who had reached the age of 30 showed signs of early involution, marked by an increase of interstitial connective tissue, and a great scarcity of Graafian follicles. Even in those much below this age, there was a distinct diminution of the follicles, as compared with a normal woman of the same age. As an instance, the greatest number of follicles at one level, found in one case aged 19, at death, was fifty-nine, whereas in a control ovary from a girl aged 24, there were 171 follicles at one level; and in another aged 17, there were 454 counted at one level.

*Imbecility with or without Epilepsy.*—These ovaries did not present a uniform type. Some quite young persons showed early involution, while in others there were a proportionately large number of follicles. In one case, for instance, of congenital imbecility with epilepsy, aged 39 at death, 123 follicles were found at one level, and no true corpora lutea.

*Melancholia.*—(Many of these cases are probably mania depressiva, as true melancholia is met with at the involutional period.) Here we find a definite diminution of follicles. The greatest number at any one level was forty, in the ovary of a woman aged 23,<sup>1</sup> and a number of these were undergoing cystic degeneration, and showed no trace of an ovum. In the majority of cases, the numbers found at one level ranged from three to fifteen, and the stroma showed a marked increase of fibrous tissue, and some thickening of the walls of the blood-vessels.

*Mania.*—In all these cases a marked diminution of follicles was found, the largest number at any one level being thirty-two, in a woman aged 32.

*General Paralysis.*—Here there was likewise a decrease in the number of follicles, the greatest number in any one case at any one

<sup>1</sup> It is probable this was a case of dementia præcox.—F. W. M.

level amounting to forty, with the exception of a case of juvenile general paralysis, aged 20, where the largest number amounted to 160 at one level. There was a marked increase of fibrous tissue, and thickening of the walls of the blood-vessels, some of which were almost obliterated.

#### CONCLUSIONS.

It would appear from the above results, that where there is disease of the brain, or mental incapacity associated with it, the power of the individual to reproduce her kind, if not absolutely cut off, is at least diminished, and in most cases an early cessation of the ovarian functions seems to take place. These facts argue that there is an intimate relation between the ovary and the brain, and confirm Ceni's statement on this point.

I do not in this paper intend to discuss in full as to whether the ovary plays a direct part in the internal secretion of the body, or whether its influence is only an indirect one. With regard to its histology, however, I can say that there is no part in the structure of the human ovary that leads me to suppose it can exercise a secreting function, unless it be the Graafian follicle itself. Neither the corpus luteum verum, nor the corpus luteum spurium, show in their composition anything resembling epithelial cells, and it is these two bodies, more especially the atretic follicle, which in the lower animals are credited with the function of secretion. After a careful study of all the ovaries, normal or otherwise, that come under my notice, I can only confirm Fraenkel's statement, that in the human ovary there are no groups of epithelioid cells corresponding to those found in the rabbit and other animals, and representing the "glande interstitielle" of Limon.

My thanks are due to the London County Council Asylums Committee for kind permission to work in the Laboratory, to Dr. Mott for his suggestions and help, and to Mr. Charles Geary for kindly taking the photographs which illustrate this paper.



TABLE I.

No.	Nature of disease	Age at first attack	Age at admission	Age at death	Condition of ovaries	Menstruation	Pregnancies and results	Married or Single
1	Dementia præcox	19	19	24	Connective tissue increased; 11 ova at one level; some corpora lutea present	Regular until one year before death	Nil	Single
2	Dementia præcox	29	30	33	38 follicles at one level; some corpora lutea present	Began at 13; ceased two years before death	Nil	Single
3	Stupor and rapid mental enfeeblement	39	39	39	Advanced involution; no follicles detected; no corpora lutea seen	Began at 14 and ceased seven months before death	Nil	Married
4	Dementia præcox; delusional insanity	19	19	19	59 follicles at one level; no true corpora lutea noticed	No history	Nil	Single
5	Suicidal dementia	24	32	34	35 follicles at one level and mostly immature ones; a few small corpora lutea vera present	Began at 16; irregular during mental attacks	Nil	Single
6	Chronic mania; dementia præcox; progressive deterioration	29	29	32	Marked increase of connective tissue; 18 follicles at one level; all immature, corpora lutea vera present	Ceased a few months before death	Nil	Single
7	Delusional insanity	33	34	36	Excess of connective tissue; 6 follicles at one level; corpora lutea vera present	Menorrhagia for thirteen years, regular up to time of last illness	Three children, none living	Married twice
8	Primary dementia; katatonia; dementia præcox	28	29	30	Connective tissue increased, only 3 follicles at one level	Began at 14; irregular; ceased twelve months prior to admission	Nil	Single
9	Katatonia	30	30	37	Excess of connective tissue, only 2 follicles at one level	No history	Three children, last one born 6 weeks prior to admission	Married
10	Dementia præcox	25	25	30	Great increase of connective tissue; 12 follicles at one level; a few corpora lutea vera present	Regular	Nil	Single
11	Dementia præcox	17	19	26	25 follicles at one level; corpora lutea vera present	Normal during detention	Nil	Single
12	Dementia with increasing stupor	25	25	29	32 follicles at one level; some small corpora lutea vera present	Very irregular	Nil	Single

No.	Nature of disease	Age at first attack	Age at admission	Age at death	Condition of ovaries	Menstruation	Pregnancies and results	Married or Single
13	Dementia præcox	23	25	29	16 follicles at one level; small corpora lutea vera present	Began at 18, ceased just before death	Nil	Single
14	Dementia with increasing stupor	29	36	41	3 follicles at one level; some increase of connective tissue; corpora lutea vera present	Did not occur during detention	Nil	Single
15	Dementia præcox	28	29	32	Connective tissue increased; 3 follicles at one level	No history	Nil	Single
16	Dementia præcox	24	26	30	6 follicles at one level; connective tissue increased; corpora lutea vera present	Occurred at irregular intervals during detention	One child living	Married
17	Dementia præcox	26	26	27	25 follicles at one level; connective tissue somewhat increased; corpora lutea vera present	Regular up to admission; did not occur during detention	One child, 4 years old, living	Married
18	Paranoid dementia, præcox	25	25	34	6 follicles at one level; small corpora lutea vera present	Dysmenorrhœa during detention; ? previous history	Nil	Married
19	Dementia præcox	26	26	32	8 follicles at one level; connective tissue increased; corpora lutea vera present	Normal during detention	Nil	Married
20	Stuporose insanity	34	34	35	No follicles detected	Began at 13; history of regularity	Two miscarriages, two still born, none living	Married thirteen years
21	Confusional insanity	34	34	34	10 follicles at one level; excess of connective tissue; a good many corpora lutea vera present	Regular until three years before admission	Nil	Widow, married for three years
22	Epilepsy with dementia	18	31	36	108 follicles at one level; a few small corpora lutea vera present	Free and regular; last time fourteen days before death	No history, but there are abdominal striae present	Single
23	Cretin	Congenital	28	29	13 follicles at one level	Irregular	Nil	Single
24	Congenital imbecility minus epilepsy	Congenital	18	25	13 follicles at one level; connective tissue increased; corpora lutea vera present	Never occurred	Nil	Single
25	Imbecile with congenital epilepsy	Congenital	32	37	5 follicles at one level; connective tissue increased; large corpora lutea vera present	Regular till about three months before death	Nil	Single

26	Congenital imbecility minus epilepsy	Congenital	30	33	51 follicles at one level	Regular	Nil	Single
27	Congenital idiocy with epilepsy	Congenital	15	18	18 follicles at one level; no true corpora lutea noticed	Never occurred	Nil	Single
28	Congenital idiocy with epilepsy	Congenital	22	22	12 follicles at one level	Never occurred	Nil	Single
29	Epileptic imbecile	Congenital	35	38	Only a few isolated follicles present; numerous corpora lutea vera	Irregular	Abdominal striae present; no history	Single
30	Insanity with epilepsy	34	34	36	17 follicles at one level; some increase of connective tissue; a few corpora lutea vera present	Regular, menorrhagia	Nil	Single
31	Epileptic	12	23	24	204 follicles at one level	Regular	One child	Married 54 years
32	Epileptic idiot	—	24	28	43 follicles at one level; true corpora lutea present	Regular; occurred three weeks before death	Nil	Single
33	Imbecility with epilepsy	Probably congenital	16½	23	4 follicles at one level; connective tissue increased; small corpora lutea vera present, but the spuria predominate	No date of onset; menorrhagia during detention	Nil	Single
34	Imbecility with epilepsy	Congenital	18	24	25 follicles at one level; connective tissue increased	Normal; date of onset not known	One child	Married
35	Imbecile	Congenital	24	24	96 follicles at one level; corpora lutea vera present	Amenorrhoea; ? past history	Nil	Single
36	Imbecility with epilepsy	Probably congenital	18	21	45 follicles at one level; no true corpora lutea	Began at 19, ceased shortly before death; appears to have been regular	Nil	Single
37	Imbecile	—	24	24	6 follicles at one level; corpora lutea vera present, but the spuria exceed them in numbers	No history	Nil	Single
38	Epilepsy; feeble-minded	Six weeks old	15	22	6 follicles at one level; no true corpora lutea vera present	Very irregular	Nil	Single
39	Idiocy with epilepsy	Congenital	34	39	123 follicles at one level; a few small corpora lutea vera present	Never occurred	Nil	Single
40	Idiocy with epilepsy	Congenital	15	19	3 follicles at one level; considerable increase of connective tissue; no corpora lutea vera	Irregular	Nil	Single
41	Insanity with epilepsy	22	22	27	31 follicles at one level	Profuse dysmenorrhoea	Nil	Single
42	Stupor; ? dementia præcox	17	17	33	Very few follicles detected; connective tissue increased	Regular	Nil	Single
43	Intelligence of low order; dull and apathetic; epileptic, imbecile	2	14½	17½	14 follicles counted at one level, some dilated; corpora lutea vera present, but the spuria predominate	Ceased three years prior to admission	Nil	Single

No.	Nature of disease	Age at first attack	Age at admission	Age at death	Condition of ovaries	Menstruation	Pregnancies and results	Married or Single
44	Insanity with epilepsy; typical insane epileptic temperament	21	23	26	500 follicles at one level, also a good many cystic dilatations of follicles; corpora lutea vera present	Began at 18, usually irregular	Nil	Single
45	Imbecile	Congenital	28	29	Only three follicles at one level; considerable increase of connective tissue; Corpora lutea vera present	Regular; began at 17	Nil	Single
46	Very slight intelligence	Congenital	18	21	36 follicles at one level; no true corpora lutea	Did not occur during detention.	Nil	Single
47	Low type of imbecile	Congenital	15½	25	15 follicles at one level; corpora lutea vera present	Began at 15	Nil	Single
48	Organic brain disease, imbecile	16	16	18	Crowds of small follicles, also dilated ones; no definite corpora lutea noticed	Never occurred	Nil	Single
49	Idiocy with epilepsy	Congenital	15	19	41 follicles at one level, some quite dilated with healthy-looking ova	Never occurred	Nil	Single
50	Congenital idiocy	Congenital	17	25	3 follicles at one level	Occurred about every three months	Nil	Single
51	with epilepsy	Congenital	25	29	7 follicles at one level; corpora lutea vera present	Never occurred	Nil	Single
52	Congenital idiocy minus epilepsy	Congenital	18	25	274 follicles at one level; some small corpora lutea vera present, but the spuria predominate	Very irregular; ceased some time before death	Nil	Single
53	Insanity with epilepsy	19	35	41	2 immature follicles only; advanced involution; a few small corpora lutea vera present	Very irregular	Nil	Single
54	Imbecile	Congenital	22	31	42 follicles at one level; a few small corpora lutea vera present	Began at 10 years	Nil	Single
55	Feeble-minded; memory defective; dull and apathetic	35	36	36	6 follicles at one level; corpora lutea vera present	Began at 13; continued regularly	2	Married
56	General paralysis of the insane	42	43	44	Marked increase of connective tissue; a few isolated follicles only	No history obtainable	15	Married twice
57	Organic brain disease	35	35	37	6 follicles at one level; corpora lutea vera present	Once during detention	1	Married six years

58	Progressive general paralysis	38	38	41	Involution advanced; very few follicles present	Regular	One child	Married
59	General paralysis	34	34	38	28 follicles at one level, mostly immature; numerous small corpora lutea vera	No history; absent during detention	Four children, all living	Married
60	General paralysis	43	43	43	11 follicles at one level; a good many corpora lutea vera	No history; absent during detention	No history; abdominal striae present	Married
61	General paralysis, beginning with maniacal symptoms	38	40	41	Involution advanced, only one or two isolated follicles seen	No history obtainable	Several miscarriages	Married
62	General paralysis	36	36	38	4 follicles at one level; some large corpora lutea vera present	Twice during detention	4	Married four-teen years
63	General paralysis	36	38	43	Advanced involution, only 2 follicles noticed	Did not occur during detention	5	Married fifteen years
64	General paralysis	?	21	24	40 follicles at one level; corpora lutea vera present	Nothing known	Nil	Single
65	General paralysis of the insane	40	40	41	Involution advanced; 5 follicles at one level, mostly degenerating; numerous corpora lutea vera	Frequent and excessive	3; first and second miscarried, third died soon after birth	Widow
66	General paralysis	27	29	30	Only 2 follicles at one level	Regular; began at 15, ceased shortly before death	Nil	Single
67	General paralysis	26	26	26	23 follicles at one level; a few corpora lutea vera present, but the spuria predominate	Did not occur during detention	Nil	Single
68	General paralysis	35	35	36	Both ovaries consist of a narrow band of normal stroma enclosing a mass of corpus luteum tissue; in the normal tissue there are 42 follicles at one level	No history obtainable	Abdominal striae present	Married
69	General paralysis	39	39	41	Involution almost complete	Occurred only once during detention; began at 15	?	Married one year
70	Juvenile general paralysis	19	19	20	160 follicles at one level; some large corpora lutea vera present	Regular until just before admission; began at 15	Nil	Single
71	General paralysis	43	43	44	Advanced involution; no follicles detected	No history obtainable	Thirteen children	Married
72	General paralysis, demented type	35	35	38	Involution advanced; 11 follicles at one level; corpora lutea vera present	Regular till eighteen months before admission	Nil	Single
73	General paralysis	37	38	39	34 follicles at one level, some dilated; corpora lutea vera present, but the spuria predominate	Ceased three years prior to admission	One child living	Widow

No.	Nature of disease	Age at first attack	Age at admission	Age at death	Condition of ovaries	Menstruation	Pregnancies and results	Married or Single
74	Melancholia	44	44	44	Only 3 follicles at one level	Occurred during detention	Six children living	Married
75	Melancholia; suicidal at an early stage	41	41	46	A few isolated follicles present; involution almost complete; a few corpora lutea vera present	Three times during detention	<i>Nil</i>	Married twenty-one years
76	Melancholia	39	39	39	Only two follicles at one level	Began at 16; ? regularity	<i>Nil</i>	Single
77	Chronic melancholia	38	41	44	5 follicles at one level; corpora lutea vera present	Regular during detention; occurred five days before death	History defective	Married
78	Melancholia	26	29	33	9 follicles at one level; marked increase of connective tissue	Began at 14; history of regularity	Three	Married
79	Melancholia	34	36	40	8 follicles at one level; excess of connective tissue; corpora lutea vera present	Began at 14; fairly regular	Seven; last child born six weeks prior to admission	Married
80	Melancholia agitata	27	27	27	3 follicles at one level; connective tissue increased; some small corpora lutea vera present	Did not occur during detention	<i>Nil</i>	Single
81	Melancholia	28	28	37	Involution almost complete; 3 follicles at one level; corpora lutea vera present	Regular	Seven; three children living	Married
82	Melancholia	24	34	39	Only 1 follicle noticed	Regular and profuse	<i>Nil</i>	—
83	Melancholia	35	36	36	4 follicles counted at one level; a few dilated ones; corpora lutea vera present	History of irregularity	One child living, 8 years old	Married
84	Puerperal mania, which became chronic	34	34	41	Advanced involution; 6 follicles at one level; some large corpora lutea vera present	Regular	Four; three children living	Married
85	Mania	41	42	44	Advanced involution; only a few isolated degenerated follicles found	No history	<i>Nil</i>	Married
86	Mania with epilepsy	?	27	28	Excess of connective tissue; 3 follicles at one level	Not regular; occurred three times during nineteen months' detention	<i>Nil</i>	Single

87	Mania with epilepsy	20	23	30	3 follicles at one level	Regular : occurred one month before death	Nil	Single
88	Mania with imbecility	?	22	32	Connective tissue increased; 32 follicles at one level; corpora lutea vera present	Dysmenorrhoea; ? commencement	Nil	Single
89	Mania with epilepsy	22	22	24	24 follicles at one level; no corpora lutea vera noticed	Ceased two months before admission	Nil	Single
90	Mania	33	33	33	6 follicles at one level; connective tissue increased; corpora lutea vera present	No history obtainable	One child	Married
91	Recurrent mania	29	29	29	5 follicles at one level; interstitial connective tissue increased	No history obtainable	Nil	Single
92	? Acute mania	21	21	21	8 follicles at one level; corpora lutea vera present	Regular	Nil	Single
93	Mania	?	16	40	3 follicles at one level; some large corpora lutea vera present	Irregular; scanty	Nil	Single
94	Acute post-puerperal mania	26	26	30	39 follicles at one level; connective tissue increased	Did not occur during detention	One child born three weeks prior to admission	Married
95	Died after recent pregnancy	24	24	24	5 follicles at one level; some small corpora lutea vera present	Regular	Two	Married
96	Consciousness clouded, confusion, hallucinations	22	26	34	10 follicles at one level; no dilated ones; corpora lutea vera present	Nil noted	Two; youngest thirteen months old	Married
97	Degenerate in mind and body	23	23	23	40 follicles at one level; connective tissue increased; mostly degenerated	Began at 16	Nil	Single
98	Melancholia	37	37	37	30 follicles at one level; connective tissue increased; several corpora lutea vera present	Once during detention	Nil	Single
99	Mania	22	23	34	3 follicles at one level; a few corpora lutea vera present	No history obtainable	Nil	Single
100	Epileptic	38	38	41	Involution advanced; very few follicles present; a few corpora lutea vera present	No history	Nil	Single
101	Epilepsy with mania	Two previous attacks	24	42	Involution advanced; very few follicles; a few corpora lutea vera present	No history	Nil	Single

TABLE II.—CONTROL OVARIES OF PERSONS NOT AFFECTED WITH MENTAL DISEASE.

No.	Age	Cause of death	Condition of ovaries
A	30	Corrosive acid poisoning	Graafian follicles not numerous, 9 at one level; connective tissue much increased; numerous corpora lutea vera present
B	33	Cirrhosis of liver	12 follicles at one level; a good many degenerate follicles which contain no ova; numerous corpora lutea vera; connective tissue increased
C	4	Extensive burning	Innumerable follicles present, some of which are much dilated; no corpora lutea of any description noted
D	4 days	Pneumonia	Innumerable follicles, a number of which are dilated; no corpora lutea of any description
E	25	? Poisoning	Follicles at all stages of development; 81 at one level
F	7 months	Catarrhal gastritis and enteritis	Innumerable follicles, many dilated ones; no corpora lutea of any description noticed
G	32	Heart failure; chronic interstitial nephritis	No ova detected; involution appears complete; numerous corpora lutea vera present
H	17	Heart failure; diabetes	454 follicles counted at one level, some of which are considerably dilated; a few corpora lutea vera and spuria present
I	35	Cerebral hæmorrhage; chronic interstitial nephritis	Very few follicles present, and these are mostly degenerating; increase of connective tissue and thickening of blood-vessel walls; many corpora lutea vera present
K	24	Diabetes	171 follicles at one level; connective tissue somewhat increased and walls of blood-vessels thickened; corpora lutea vera and spuria present
L	31	Carcinoma recti	78 follicles at one level; corpora lutea vera and spuria present
M	35	Chronic empyema	14 follicles counted at one level; corpora lutea vera present
N	28	Exophthalmic goitre	10 follicles at one level; corpora lutea vera present

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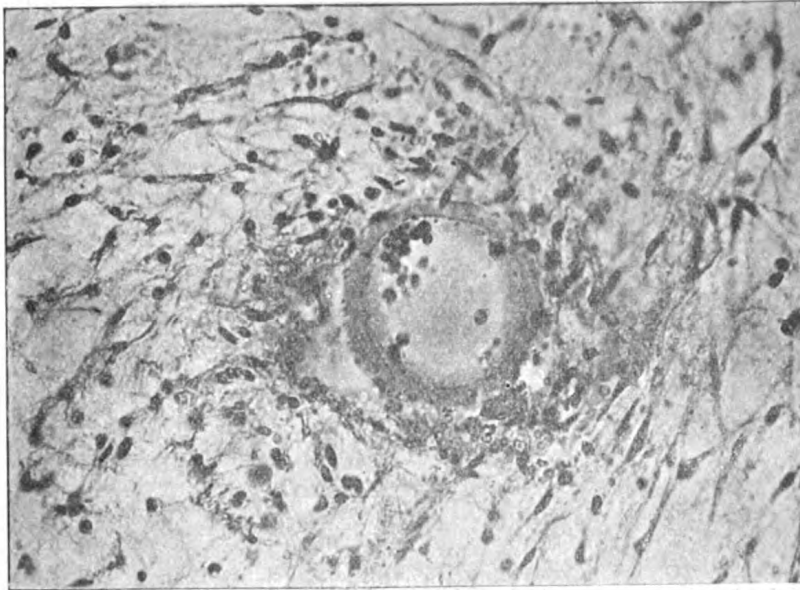


FIG. 2.  
The same as fig. 1. ( $\times 300$ .)

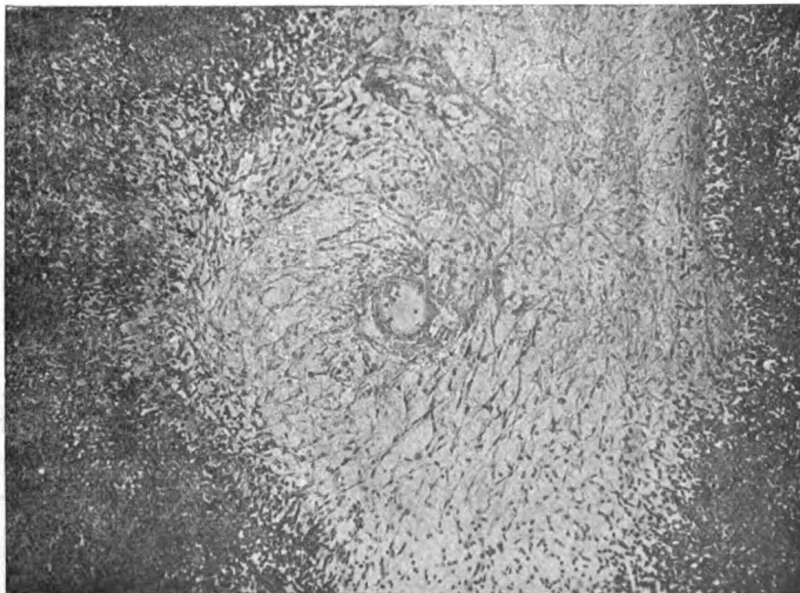


FIG. 1.  
L. S., aged 25, congenital imbecile. Connective tissue proliferation round degenerating ovum, and formation of corpus luteum spurium. ( $\times 85$ .)

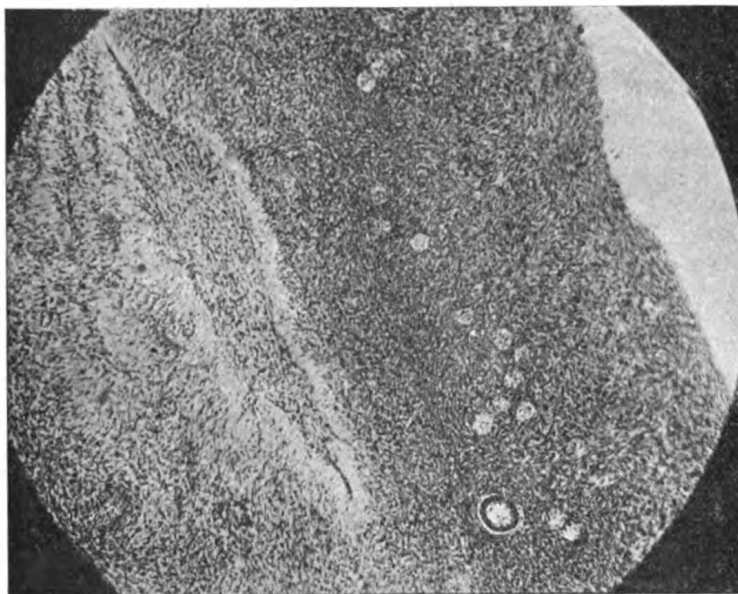


FIG. 4.

Control ovary, aged 24. Edge of ovary with Graafian follicles and corpus luteum spurium. ( $\times 85$ .)

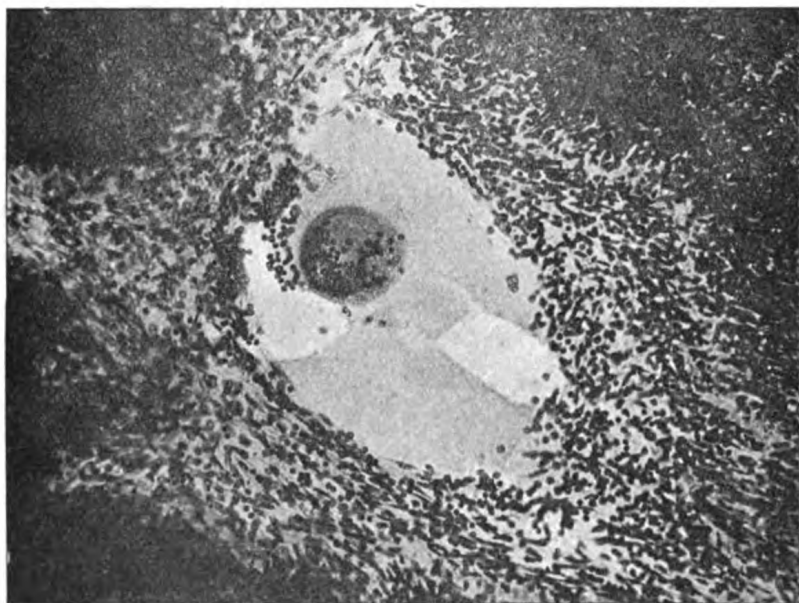


FIG. 3.

L. E., dementia praecox, aged 23. Beginning of connective tissue proliferation round degenerating ovum. ( $\times 180$ .)

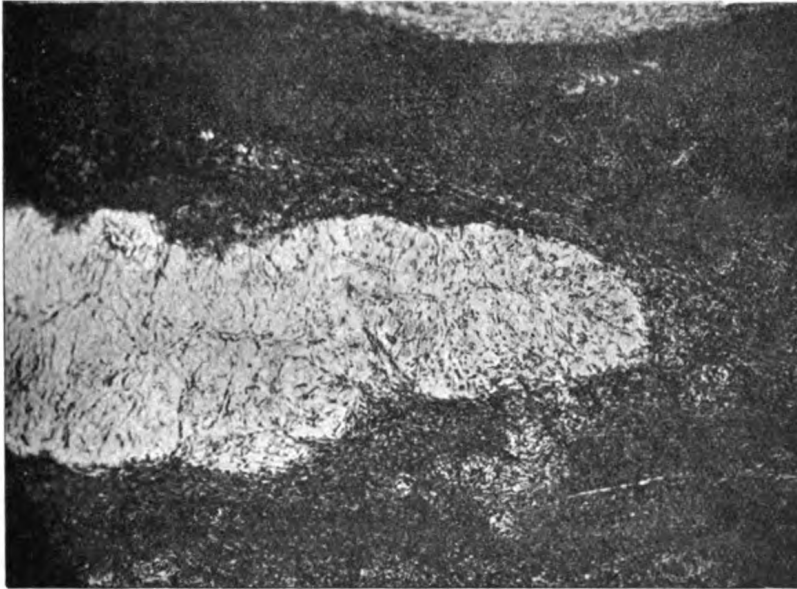


FIG. 6.

E. W., aged 41, general paralysis of the insane.  
Corpus luteum verum surrounded by ovarian stroma.  
( $\times 85$ .)

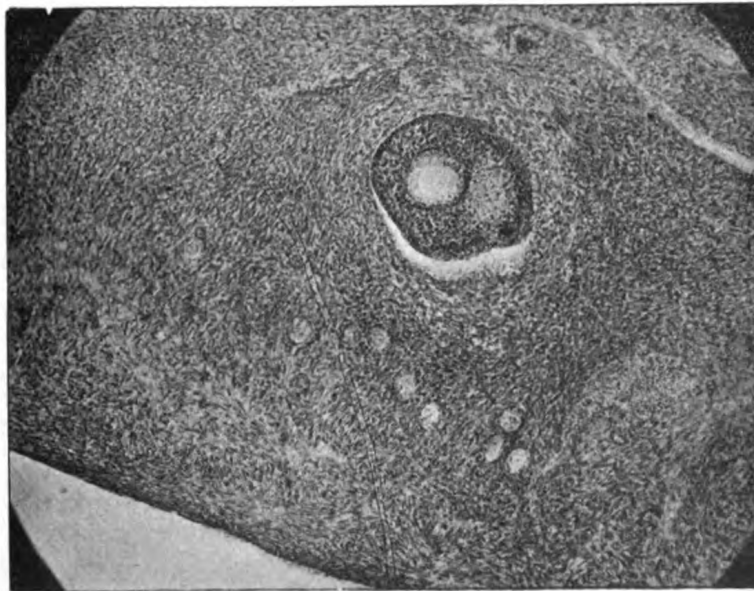


FIG. 5.

Control ovary, aged 24. Edge of ovary with Graafian  
follicles. ( $\times 85$ .)

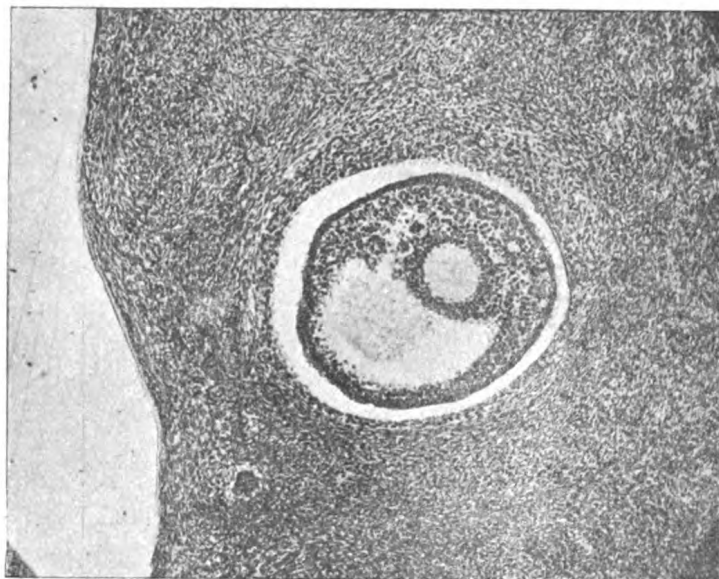


FIG. 8.

N. F., aged 39, general paralysis of the insane.  
Edge of ovary with Graafian follicle embedded in the  
stroma. ( $\times 85$ .)

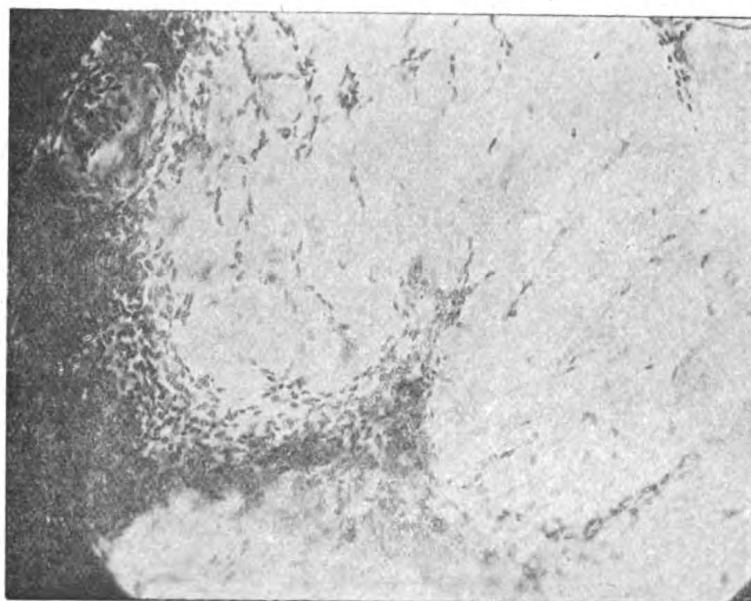


FIG. 7.

Control ovary, aged 33. Portion of corpus luteum  
verum. ( $\times 200$ .)

ADDENDUM BY F. W. MOTT, Major R.A.M.C.(T.), M.D., F.R.S.

Before the outbreak of the War Dr. Laura Forster handed me the paper which has just been read. Unfortunately she immediately left England and I was unable to communicate with her. But for this I should have suggested some modifications and additional microscopic investigations of the sections which she has prepared with so much diligence. I must publish the paper as it was written, for her death has been recently announced, which is greatly to be regretted, as she was an earnest worker for whom I had great respect. I thought it desirable, however, from a study of the great number of sections made by Miss Forster to write a commentary, which, had she lived, I would have asked her to consider with a view to its partial or complete embodiment in her paper.

This investigation is beset with many difficulties, and I think that if fewer cases with perfect notes had been selected more convincing results would have been obtained. Still the large number of cases studied permits some generalizations to be made which a smaller number would not do. Among the difficulties which Miss Forster had to contend with was the possibility of variable diagnosis of the mental disease by the medical officers in charge of the cases. Again, her observations show that chronic diseases of long standing—e.g., nephritis, chronic endocarditis, and diabetic cirrhosis—may cause follicular degeneration and fibrotic atrophy. Lastly, it is difficult to make a complete histological examination of the ovary; for owing to its structure the paraffin method cannot be employed for serial sections with advantage, and it was found that the only satisfactory mode of procedure was to embed the material in celloidin. The blocks were cut and each section was laid out in series on glass plates, examined with a low power objective, and then, if a particular follicle was required to be studied, the series containing it was stained and mounted.

Nevertheless, taking into consideration the large number of ovaries thus carefully examined by Miss Forster, and fully admitting the difficulties of drawing certain conclusions owing to the complicating causes mentioned, I am of opinion that her work establishes the fact that there is a correlation between certain types of mental disease and morbid changes in the ovaries. I have not liked to add my own views to her communication without consulting her. I have, therefore, given it as she handed it to me. If it had been possible, I should have asked

her to more carefully consider the following points in relation to the morbid histology of the ovaries and their possible association with certain types of mental disease. The corpora lutea vera she very properly distinguishes from the corpora lutea spuria, or, as I should prefer to name them, the corpora atretica. The former are the result of the maturation and rupture of normal Graafian follicles, the latter are the result of invasion of a degenerate follicle by the stroma of the gland. It is permissible to assume that the existence of a large number of the former of large size is evidence that for some considerable time during the possible reproductive life of the woman healthy follicles were maturing and rupturing. Consequently a comparison of the relative numbers and size of the corpora lutea vera in relation to (a) the age of onset of the mental disease and age at death, associated with (b) history of menstruation when obtainable would have been valuable. Some idea might be gathered, therefore, when the normal ovarian function of follicular maturation ceased, and how far this could be connected with, or be considered coincident with, the onset and progress of the mental disease.

But suppose the follicles, instead of bursting, undergo degeneration with their contained ova and form the corpora atretica, we then have evidence of a morbid condition, consequently the relative numbers of the corpora atretica to (a) corpora lutea vera, (b) the age of onset of the mental disease and age at death, would afford some indication when normal follicular maturation ceased (if it ever occurred), and how far the appearance of the degenerative follicle could be connected with, or considered coincident with, the onset and progress of the mental disease. The examination of a large number of the sections prepared by Miss Forster has impressed me with two facts, viz., that there is evidence to show that the normal maturation of the follicle and formation of the corpus luteum verum tends to cease and be replaced by the degeneration of the follicle with the onset of certain types of mental disease. I will, therefore, consider a little more fully the characteristics which serve to distinguish the degenerate or atretic follicle from the true corpus luteum, and subsequently I will refer to the particular cases which illustrate the premise I have stated.

(1) The atretic or degenerate follicle exhibits no indication of rupture to the exterior.

(2) The follicular epithelium forming the zona granulosa and discus proligerus instead of hypertrophying degenerates, separation from the wall and fragmentation occurs, the chromatin substance instead of

appearing as a distinct nucleus is seen as fine points in the cytoplasm, much smaller than the nucleus. They lose their basophil staining reaction, break up eventually and become unrecognizable as cells, finally disappearing altogether. Hæmorrhage into the degenerate follicles is very liable to occur.

(3) The ovum is retained in the follicle but undergoes degenerative changes, it may lose its regular circular shape, the zona pellucida persisting. The germinal vessels and germinal spot lose their circular form and have an irregular appearance; the ovum may shrink away from the zona pellucida and finally it may be invaded by cells.

(4) The connective tissue wall does not proliferate to form a network among the epithelial cells as occurs in the true corpora lutea, and there is usually no ingrowth from the theca until the epithelial cells are in an advanced stage of degeneration or have altogether disappeared.

Such degenerative changes may occur in all stages in the development of the follicle, and not merely in the fully formed follicle that has failed to rupture. Atretic follicles may continue for a time as cysts which remain filled with fluid.

Heape has shown that in the rabbit two kinds of degeneration prevail: in the one kind the changes first affect the follicle then the ovum; in the other the ovum is first affected and the follicle afterwards. Heape interprets the latter change as evidence that the ovum is not capable of assimilating the nourishment brought to it. The more usual cause of degeneration in immature follicles is lack of sufficient nutriment or of nutriment of the requisite kind. (Marshall, "Physiology of Reproduction.")

I have examined sections from the following cases on the lines indicated:—

(1) A cretin, S. B., aged 28 on admission to Leavesden; died at the age of 29. No corpora lutea vera seen; atretic follicles, a few immature follicles, and dense fibrous tissue. In the left ovary, in addition, the organ is the seat of a large blood cyst.

(2) A. B., aged 18 on admission to Leavesden; age at death, 21. Never menstruated. No sign of mature Graafian follicles, a few atretic follicles, very few small corpora lutea, paucity of immature ova.

(3) M. T., admitted to Leavesden, at the age of 18, suffering with idiocy and epilepsy; never menstruated; died at the age of 22. Excessive fibrosis; many atretic follicles in various stages. A Graafian follicle of small size with discus proligerus, and ovum with zona pellucida observed. The ovum shows

the first stage of degeneration. There is a vacuolation in the place of the germinal vessels and germinal spot.

(4) A. S. P., aged 23 at death. Dementia præcox. Died of tuberculosis. Interstitial connective tissue much increased. Very few immature follicles. Atretic follicles, hæmorrhage into one of them. One ovum in a dilated follicle seems to be dividing into segments; the zona pellucida appears normal. There is a hæmorrhage into the cavity of the follicle; it no longer contains any epithelial lining cells. Corpora lutea vera, a few present.

(5) E. M. S., aged 30 at death. Post-puerperal mania. There has been some chronic inflammatory process, for the ovarian tissue seems quite encapsuled in connective tissue. A small Graafian follicle seen with normal ovum; discus proligerus and zona granulosa.

(6) B. W., aged 33 at death from cirrhosis of liver and ascites. Charing Cross Hospital. The ovaries are large and weigh respectively: Right, 13·9 gm.; left, 20·2 gm. The increase in size is due to a number of degenerate follicles of varying size; there are also a number of corpora lutea vera. There is an increase of dense fibrous tissue, which, by its contraction around the cysts, gives a nodular appearance to sections of the gland. There are only a very few immature follicles. I have seen several ovaries of chronic drunkards presenting this appearance. The corpora lutea vera may be regarded as evidence of normal follicular maturation in earlier life before the effect of the alcohol had produced the morbid change and degeneration.

(7) E. F., admitted to Bexley for melancholia at the age of 29; died aged 33. Few corpora lutea vera; great increase of connective tissue; many atretic follicles.

(8) A. M., admitted to Bexley at the age of 22; died at the age of 31. Right ovary, 16 gm.; left ovary, 16 gm. The large size of the ovaries is due to corpora lutea vera in fair numbers, increase of connective tissue, and a large number of atretic follicles.

(9) L. M. S., admitted to Bexley at the age of 25 for dementia præcox; died at the age of 30; right ovary, 3·7 gm.; left ovary, 3·7 gm. The section shows fibrotic atrophy in a remarkable manner. There are only a few scattered immature follicles. Atretic follicles are seen in all stages of degeneration. There are hardly any corpora lutea vera present in either ovary. There is a great increase of connective tissue and some thickening of the vessels.

(10) E. T., aged 19, admitted to Long Grove with juvenile general paralysis; died at the age of 20. Menstruation ceased prior to admission; previously regular. Crowds of follicles in both ovaries. A few rather large corpora lutea. A number of atretic follicles.

(11) O. H., admitted to Horton at the age of 19 for dementia præcox: died at the age of 26. Right ovary, 14 gm.; left ovary, 9·5 gm. Although the



ovaries are large there are only a few small corpora lutea. The glands are very vascular and the vessels are dilated and congested. There are numbers of atretic follicles in all stages of degeneration and subsequent fibrotic change.

(12) L. L. N., admitted to Manor Asylum. Diagnosis, mania with epilepsy, at the age of 22; died at the age of 24. Menstruation ceased two months before admission. Right ovary, 3 gm.; left ovary, 2·5 gm. No corpora lutea vera seen. Intense congestion. Hæmorrhage into all the follicles. Zona granulosa separated and fragmented. Very marked congestion of discus proligerus, probably the result of status epilepticus. It may be that the congestive stasis of epilepsy would cause follicular destruction.

Assuming that the degeneration of the follicles may arise from two causes: (1) Nutritional, depending upon the quality and quantity of the blood supply to the organ; (2) germinal—the specific vitality of the follicle and especially of the ovum, it is desirable in any future investigation to study particular methods by which the finer histological changes in the ovum can be recognized, so as to determine whether in certain forms of insanity occurring in adolescence, e.g., dementia præcox, a primary degeneration of the ovum occurs, recognizable in the immature follicles.



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## **The Ductless Glands in 110 Cases of Insanity, with Special Reference to Hypothyroidism.**

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### **INTRODUCTION.**

Part I: Source of material—Weight of ductless glands and tabulated statement—Comparative results and inferences—Conclusions regarding the weights of the ductless glands in the insane.

Part II: Microscopical investigation of the ductless glands and reproductive organs in hypothyroidism. Conclusions.

### **· INTRODUCTION.**

I have been engaged upon the investigation of the ductless glands in the insane at the suggestion and under the direction of Dr. Mott, F.R.S., &c., the Director of the Laboratory, to whom I express my sincere and deepest gratitude for the help and encouragement he has always so readily given me during my work. I am indebted to Dr. R. Armstrong-Jones for the clinical records of the cases, of which I shall give brief notes. The influence of the ductless glands upon bodily and mental functions in health and disease has formed the subject of a number of investigations, and much detailed information has been obtained, but our knowledge is still incomplete. There is a large amount of evidence to show that there is a functional correlation between the ductless glands and the nervous system, and the following investigation was undertaken to ascertain the extent of the changes to be found in the ductless glands of the insane. I intend first to give brief notes regarding the comparative weights of the glands in 110 consecutive autopsies, and follow with a description of four cases of hypothyroidism that occurred in the series.

I wish to express my best thanks to Messrs. Geary and Mann for their technical help throughout my work.

<sup>1</sup> From the Pathological Laboratory, Claybury Asylum.

## PART I.

## SOURCE OF MATERIAL.

Through the courtesy of Dr. Mott who made the post-mortem examinations, I have obtained all the material from 110 consecutive autopsies at Claybury Asylum. All the ductless glands were carefully removed from the body and freed from surrounding tissue, and carefully weighed. Those glands in which tumours or large cysts were found were not included in the series—e.g., those cases in which the ovaries were disintegrated owing to adhesive salpingitis, and the adrenals that could not be removed from the body without destruction. I was, generally speaking, fortunate enough, however, to obtain the material within a short time of death and without any signs of post-mortem change. To remove the external parathyroid I have taken special care to remove the organs of the throat entire, and then to dissect out the parathyroid according to the method of Erdheim, Getzowa, Rogers, and Ferguson.

## WEIGHT OF DUCTLESS GLANDS AND TABULATED STATEMENT.

The weight of the thyroid gland in 110 male and female cases was found to vary considerably. The average weight in the male was 16.46 gm., and in the female 16.87 gm. The minimum weight in the male cases was 4.4 gm., and in the female cases was 4.5 gm. In both sexes between the ages of 30 and 50 there appears to be a comparative increase in the weight of the gland. The average weight in both male and female is extremely low, as compared with the minimum weight for the gland in other than mental cases given by various authors. In six male cases (12 per cent.) and eleven female cases (18 per cent.) the thyroid weighed less than 10 gm. (*see* Tables I to IV, pp. 4-13).

According to Ewald, v. Eiselsberg, Testut, Marine and Lenhart, and others, the normal minimum weight varies from 22 to 25 gm. According to Weibgen the gland in the male is larger than in the female, so that the mean weight of the gland in the female is 29.3 gm., whilst in the male it is 34.2 gm. It seems that in the asylum cases the average weight of the gland in the female is practically the same as that of the male. The maximum weight in the female is, generally speaking, greater than the maximum weight in the male, and there appears to be a much greater variation in the weights of the female cases than in the

male. The weight of the thyroid in proportion to the body-weight, according to Krause is 1 : 1,800 to 1,223, according to Huschke and Weibgen 1 : 1,800. The proportion in the insane is 1 : 3,232 in the male and 1 : 2,847 in the female.

The external parathyroid glands were carefully weighed in nineteen male cases and in twenty-two female cases—altogether in forty-one cases. The glands vary in number. In four male and six female cases four glands were found, each two on both sides, while in three male cases and in two female cases three glands were found, so that two glands occurred on one side of the lateral lobe of the thyroid and one on the other. In five male and three female cases only one gland was found, which in two male cases and one female case was found on the outside of the right lateral lobe of the thyroid gland, and in the remaining cases at the outside of the left lobe. In other cases of both sexes two glands were found at the outside of both lateral lobes of the thyroid gland. It is difficult to give an average weight, because the number of the glands in each case varies as above mentioned. The weight of each gland varies from 0.01 grm. to 0.07 grm. It is noteworthy that though in a case several glands were found, the weight of each gland does not show much difference. There is also no difference between glands of the right and the left sides. Yanase has found in 89 cases of children four glands in fifty cases, three in twenty-three cases, two in twelve cases, and one in four cases; Getzowa has also found four glands in one-third of 100 cases; v. Verebely in 108 out of 138 cases; Moller in two-thirds of 120 cases. I have found four glands in 21.9 per cent. of the cases. In a male with dementia præcox, aged 25, a double gland was found by microscopical examination. It is difficult to draw any conclusions respecting the relative weight of the thyroid and parathyroid glands.

The average weight of the pituitary body in the male is 0.56 grm., and in the female 0.65 grm. In the female, except those cases in which the large pituitary body has been found in conjunction with hypothyroidism, the average weight shows 0.62 grm. The smallest in the male cases is 0.22 grm., in the female cases 0.3 grm. The largest in the male is 0.9 grm., and in the female 1.2 grm., and the next one is 1.05 grm. In a female with general paralysis, aged 37, who died after a few days' illness from broncho-pneumonia after giving birth to a child, the anterior part of the pituitary body was enlarged, and weighed 0.7 grm., while the pineal gland weighed 0.15 grm., and the thyroid 14.10 grm. (*vide* Tables I to IV, pp. 4-13).

TABLE I.—FIFTY MALE CASES.  
N.B.—Body weight in kilogrammes, the other organs in grammes.

No.	Name	Age on admission	Age at death	Disease	Cause of death and complications	Weight								
						Body	Brain	Pituitary body	Pineal gland	Thyroid	Adrenals		Testicles	
											Right	Left	Right	Left
1	E. J. A.	21	21	Insanity of adolescence	Pulmonary tuberculosis	57.0	1,370	0.55	0.47	18.1	6.55	5.52	10.20	11.10
2	F. F.	25	25	General paralysis	Exhaustion of general paralysis, broncho-pneumonia	94.0	1,200	0.58	0.18	11.70	6.20	4.20	6.52	6.42
3	*E. S.	24	25	Dementia præcox	Pneumonia	46.0	1,390	0.57	0.17	18.3	8.8	10.70	21.2	16.1
4	W. L.	25	26	Adolescent melancholia	Acute dysentery, commencing pneumonia	59.0	1,360	0.60	0.10	20.1	7.80	8.90	11.00	9.89
5	E. E. H.	28	29	Congenital imbecility	Pulmonary tuberculosis, commencing tuberculosis of intestine	43.0	1,315	0.60	0.15	16.0	6.50	3.00	10.30	9.90
6	H. H.	27	34	Secondary (terminal) dementia	Pulmonary tuberculosis	51.0	1,525	0.67	0.12	23.30	8.00	8.45	10.2	10.45
7	G. W. P.	27	34	Mania	Acute dysentery, broncho-pneumonia	59.0	1,480	0.60	0.12	10.72	7.72	6.62	10.8	11.20
8	J. T.	27	34	Manic depressive insanity	Pulmonary tuberculosis, mixed infection, gangrene of lung, pneumonia	61.0	1,325	0.73	0.03	21.63	6.83	6.8	7.6	9.50
9	A. E. L.	33	35	General paralysis	General paralysis, broncho-pneumonia	55.5	1,425	0.80	0.25	13.10	6.40	5.4	21.2	17.90
10	A. C.	36	37	General paralysis	Advanced general paralysis, broncho-pneumonia with cavitation and commencing gangrene	—	1,150	0.60	0.10	26.55	10.15	7.35	13.8	13.90
11	G. H. S.	29	37	Epileptic dementia	Pleurisy, cardiac failure, fatty degeneration of heart, hypostatic congestion of both lungs	63.0	1,515	0.75	0.25	14.00	6.50	7.50	11.5	13.50

12	S. P.	35	37	Melancholia	Pulmonary tuberculosis, adhesive pericarditis	51.0	1,460	0.65	0.15	32.25	5.55	6.1	10.1	9.25
13	F. T.	37	39	Recurrent melancholia	Broncho-pneumonia	40.0	1,280	0.60	0.17	9.52	8.22	7.02	10.77	11.48
14	P. H. B.	38	39	Tabo-paralysis	Tabo - paralysis, pulmonary tuberculosis, secondary suppurative nephritis, old mitral stenosis	46.0	1,175	0.34	0.05	6.72	5.72	8.22	8.2	9.30
15	C. W. S.	39	40	General paralysis	Exhaustion of general paralysis	58.0	1,460	0.47	0.20	19.00	5.90	5.50	12.5	13.5
16	W. F. C.	40	41	Tabo-paralysis	Tabo - paralysis, sub-acute dysentery, hemorrhage into adrenals	—	1,410	0.67	0.17	12.60	13.50	5.40	12.40	11.90
17	C. A.	40	41	Epileptic dementia	Pulmonary tuberculosis	53.0	1,370	0.50	0.20	30.50	5.20	4.20	10.10	9.80
18	J. C.	24	41	Chronic mania	Broncho-pneumonia	57.0	1,490	0.90	0.15	11.60	6.40	5.70	10.20	9.80
19	H. A. R.	41	42	Epileptic dementia	Pulmonary tuberculosis, pneumonia	56.0	1,285	0.22	0.12	15.17	6.87	6.17	19.17	11.47
20	C. K.	41	42	General paralysis	General paralysis, broncho-pneumonia	47.0	1,488	0.83	—	15.10	8.80	9.10	18.80	17.50
21	C. J. G.	41	43	General paralysis	Exhaustion of general paralysis, fatty heart, broncho-pneumonia	54.5	1,370	0.80	0.25	18.00	5.50	6.50	14.50	12.60
22	C. W. S.	45	46	General paralysis	General paralysis, commencing broncho-pneumonia, purulent bronchitis, nodular fibrosis just above aortic valve, patchy fibrosis in aorta with places showing fatty change and atelectasis	56.0	1,240	0.40	0.20	30.00	8.20	7.80	12.00	12.50
23	W. S.	47	47	Acute mania	Bronchitis, broncho-pneumonia, heart failure	57.0	1,345	0.55	0.13	16.90	2.90	3.80	12.30	11.90
24	W. H. T.	46	48	Recurrent mania	Acute bronchitis tending to broncho-pneumonia	71.0	1,610	0.50	0.20	13.25	4.25	3.42	6.25	4.42
25	H. L.	48	49	General paralysis	Exhaustion of general paralysis, broncho-pneumonia	51.0	1,500	0.70	0.50	15.9	5.5	4.7	24.4	23.2
26	C. B.	50	50	Melancholia	Pulmonary tuberculosis	43.0	1,345	0.45	0.15	11.40	8.02	6.52	10.32	12.22

\* A persistent thymus was found in this case.

TABLE I—(continued).

No.	Name	Age on admission	Age at death	Disease	Cause of death and complications	WEIGHT								
						Body	Brain	Pituitary body	Pineal gland	Thyroid	Adrenals		Testicles	
											Right	Left	Right	Left
27	C. B. P.	49	50	General paralysis	Dilated aorta, bronchitis, emphysema	70.0	1,200	0.70	0.20	17.00	6.95	7.45	16.45	18.45
28	W. D.	46	51	General paralysis	Pneumonia, morbus cordis	57.0	1,245	0.70	0.10	22.30	6.10	6.50	10.92	12.50
29	R. J. Y.	31	51	Congenital imbecility	Pneumonia, stone in kidney	34.0	1,085	0.50	0.10	4.4	3.05	3.5	4.30	4.10
30	W. G.	53	54	Katatonie ecstasy of primary dementia	Obolescent tubercle, chronic renal disease, bronchitis,emphysema, arterio-sclerosis, fatty degeneration of the heart, internal hydrocephalus	52.5	1,580	0.61	0.31	6.6	3.81	3.51	10.3	10.7
31	R. P. F.	54	55	Confusional insanity	Hemorrhagic pancreatitis	59.0	1,350	0.60	—	11.7	9.9	5.6	12.5	11.2
32	W. C. W.	51	55	Melancholia	Pulmonary tuberculosis, heart failure, tubercular ulceration of intestine	43.0	1,250	0.38	0.10	8.90	3.90	2.80	—	6.10
33	J. Y.	48	57	Insanity with epilepsy	Epilepsy, heart failure	—	1,430	0.67	0.07	32.17	8.5	7.7	19.7	18.7
34	T. S.	52	59	Insanity with epilepsy	Broncho - pneumonia, gangrene of foot, heart failure	41.0	1,515	0.70	0.25	15.50	6.50	6.80	9.80	10.90
35	J. J.	55	58	Delusional insanity	Secondary carcinoma affecting nearly all the organs, especially the lungs	51.0	1,335	0.4	0.1	13.5	12.5	9.5	18.5	19.5
36	J. E. T.	56	59	Acute mania	Exhaustion of general paralysis, bronchitis, emphysema, fatty heart	51.0	1,255	0.55	0.25	30.6	6.2	6.5	11.0	10.1
37	F. L.	53	60	Senile melancholia	Cardiac failure, broncho-pneumonia, bronchitis, emphysema, arterio-sclerosis, generalised, including cerebral arteries	62.0	1,315	0.58	0.25	18.5	5.8	6.9	10.5	11.3



	38	G. W. B.	56	60	Subacute mania	Exhaustion of senile dementia, bronchitis, emphysema, heart fail- ure	46.5	1,285	0.48	0.15	12.7	3.7	3.4	12.8	10.7
	39	J. A. W.	59	60	General paralysis	Purulent bronchitis, atrophic emphysema, fatty heart	54.0	1,345	0.62	0.07	20.6	4.1	4.2	10.1	7.2
	40	H. M.	60	62	General paralysis	General paralysis, bron- cho-pneumonia	—	1,625	0.55	0.25	14.55	6.75	4.1	24.75	27.55
	41	J. W. M.	60	62	General paralysis	Gangrene of lung, arterio- sclerosis, general para- lysis, renal disease	61.0	1,270	0.45	0.2	27.7	11.5	9.3	11.5	16.5
	42	J. M.	58	63	Recurrent melancholia, epilepsy	Cancer of oesophagus, broncho - pneumonia, chronic Bright's disease, chronic cystitis	73.0	1,585	0.46	0.23	12.6	5.9	5.6	14.45	15.9
	43	A. H.	57	63	Dementia with epilepsy	Bronchitis, emphysema, arterio - sclerosis, ad- vanced chronic Bright's disease, asphyxia owing to obstruction of the glottis, opening into the trachea by a clot of mucus and blood	59.0	1,430	0.45	0.15	11.55	5.25	4.45	9.0	8.1
	44	W. R.	63	63	Senile general paralysis	Bronchitis, broncho- pneumonia, arterio- sclerosis, adenoma of right adrenal	68.5	1,420	0.6	0.15	21.00	—	17.5	14.5	18.0
	45	W. C. S.	63	64	Dementia	Pneumonia, heart failure, renal arterio-sclerosis	61.0	1,215	0.62	0.055	10.6	8.02	7.1	12.2	10.8
	46	W. T.	50	65	Alcoholic dementia	Pneumonia, arterio- sclerosis	60.0	1,265	0.5	0.1	8.65	3.55	4.25	10.3	12.35
	47	E. O.	66	66	Dementia with epilepsy	Broncho - pneumonia, aortic dilatation	57.0	1,270	0.47	0.20	13.5	6.28	7.02	15.92	14.3
	48	T. C.	48	69	Mania with epilepsy	Pneumonia, chronic Bright's disease	59.0	1,530	0.65	0.27	16.6	8.7	6.95	11.3	10.9
	49	E. D.	68	70	Acute melancholia	Fatty heart, broncho- pneumonia, calculous pyelitis	61.0	1,360	0.5	0.16	11.7	5.9	7.9	14.8	14.2
	50	R. W.	70	79	Senile melancholia	Pulmonary tuberculosis, pneumonia	69.0	1,130	0.63	0.08	17.18	6.99	6.53	14.47	13.7

TABLE II.—SIXTY FEMALE CASES.

No.	Name	Age on admission	Age at death	Disease	Cause of death and complications	Weight								
						Body	Brain	Pituitary body	Pineal gland	Thyroid	Adrenals		Ovaries	
											Right	Left	Right	Left
1	E. E.	19	19	Mental confusion	Disseminated sclerosis, broncho-pneumonia Pulmonary tuberculosis, tubercular deposits in liver, spleen, and intestine, caseous mesenteric glands	51.0	1,290	0.62	0.25	20.50	3.00	3.70	4.20	5.90
2	E. K.	22	25	Insanity of adolescence		—	1,080	0.60	0.25	20.06	8.30	9.30	2.95	1.60
3	A. H.	25	26	Primary dementia	Acute pulmonary tuberculosis, tubercular ulceration of intestine, aortic hypoplasia	48.0	1,175	0.60	0.10	9.80	3.20	2.80	2.90	2.40
4	P. A. C.	26	27	Congenital mental weakness	Septicæmia, gangrene of lung, bronchiectasis, hydrocephalus	51.0	—	0.80	—	11.50	3.50	4.70	4.23	5.02
5	F. C.	27	28	Agitated melancholia	Miliary tuberculosis pulmonalis, subacute dysentery	34.0	1,175	0.45	0.05	27.85	6.05	6.85	3.05	1.75
6	N. D.	31	33	Dementia præcox	Broncho-pneumonia	56.0	1,220	0.40	0.15	7.70	2.80	3.40	1.80	2.70
7	M. A.	31	33	Congenital mental weakness	Pulmonary tuberculosis, fatty liver	—	—	0.60	0.10	14.00	4.70	4.20	2.30	2.00
8	F. L. A.	24	34	Adolescent mania	Pulmonary tuberculosis of comparative recent origin, dysentery, fatty liver, hour-glass stomach	34.0	1,110	0.80	0.16	22.03	8.95	4.60	—	—
9	M. C.	31	35	Acute mania	Asphyxia, hæmorrhage into the bronchi of both lungs, grave anæmia	53.0	1,270	0.89	0.35	51.20	5.25	4.90	4.90	8.15
10	E. S. M.	37	37	General paralysis	Broncho - pneumonia, general paralysis	43.0	1,190	0.70	0.15	14.10	7.10	5.70	3.90	2.51

11	A. F.	32	37	Mania, post-influenza	Morbus cordis, chronic	61.0	1,280	0.62	0.27	15.95	8.40	8.10	—	9.50
12	M. E.	80	37	Melancholia	Bright's disease	39.0	1,145	0.80	0.19	11.80	4.90	3.20	4.20	4.00
13	E. S.	33	39	Dementia præcox	Pulmonary tuberculosis	42.0	1,145	0.60	0.22	13.70	4.15	1.85	3.75	1.85
14	S. S.	19	39	Recurrent mania	Broncho - pneumonia, grave anaemia	49.0	1,180	0.85	0.23	13.50	7.90	7.40	4.60	7.90
15	M. S.	35	40	Recurrent mania	Pulmonary tuberculosis, pleurisy with effusion	39.0	1,275	0.75	0.18	52.52	5.00	6.20	3.85	5.40
16	F. M. H.	39	40	Melancholia	Bronchitis, broncho-pneumonia, commencing chronic dysentery	38.5	1,275	0.45	0.10	11.40	6.20	6.80	4.50	4.90
17	B. H.	41	41	General paralysis	Broncho - pneumonia, general paralysis, plaques of syphilitic aortitis	34.5	1,035	0.73	0.12	11.50	4.15	3.87	3.41	2.82
18	S. G.	32	43	Epileptic melancholia	Broncho-pneumonia	40.5	1,275	0.76	0.13	12.48	3.16	2.25	4.32	3.85
19	E. S. H.	41	43	Subacute mania	Dysentery, old salpingitis with adhesion both sides	46.0	1,190	0.48	0.23	22.10	5.15	6.75	—	—
20	J. I. E. B.	42	43	General paralysis	Bronchitis, emphysema, general paralysis	37.0	1,045	0.58	0.15	10.10	6.00	5.25	1.50	3.10
21	A. R.	35	43	Melancholia	Bronchitis, broncho-pneumonia, brown pigmentation of heart, symmetrical gangrene of toes (great and second)	42.0	—	0.75	0.15	30.30	6.70	4.00	3.00	1.95
22	L. M.	22	43	Mania with epilepsy	Capillary bronchitis, broncho - pneumonia, heart failure	51.0	1,240	0.80	0.18	16.70	7.80	7.50	3.10	3.60
23	A. R.	43	43	Epileptic dementia	Cerebral tumour, hypostatic congestion of the lungs	47.5	1,570	0.85	—	21.65	7.65	5.95	3.45	4.65
24	E. T. L.	36	44	Melancholia	Pulmonary tuberculosis, pericarditis, chronic dysentery	27.0	1,315	0.40	0.10	13.10	3.90	3.76	3.80	3.90
25	E. M. E.	44	44	Confusional insanity (alcoholic?)	Broncho - pneumonia, hypothyroidism, old parametritis, grave anaemia	43.0	1,080	0.77	0.12	9.2	4.25	4.55	1.20	1.60

TABLE II—(continued).

No.	Name	Age on admission	Age at death	Disease	Cause of death and complications	WRIGHT								
						Body	Brain	Pituitary body	Pineal gland	Thyroid	Adrenals		Ovaries	
											Right	Left	Right	Left
26	M. A. C.	44	46	General paralysis	Bronchitis, broncho-pneumonia, general paralysis	49.0	945	0.30	0.11	12.69	4.22	3.82	3.70	6.20
27	A. B.	46	46	Confusional insanity	Broncho - pneumonia, cardiac failure, hæmorrhagic pancreatitis	42.0	1,165	0.48	0.15	10.50	6.40	6.50	0.80	0.77
28	M. T. A.	47	47	Confusional insanity	Edematous glottis, bronchitis, emphysema, hypothyroidism, myxedema, chronic Bright's disease	78.0	1,215	1.05	0.25	33.60	5.08	5.25	3.35	—
29	E. C.	46	48	Mania	Lobar pneumonia, chronic parenchymatous nephritis	53.0	1,240	0.77	0.07	9.27	7.77	13.57	1.70	1.70
30	N. S.	39	49	Epileptic mania	Subacute dysentery, bronchitis, emphysema, fatty heart, disorganised suprarenals, its cortex and medulla both affected	55.5	1,295	0.60	0.10	27.30	16.20	10.30	2.40	2.80
31	E. D.	48	49	General paralysis	General paralysis, bronchitis, broncho-pneumonia	66.0	1,085	0.55	0.20	11.10	5.45	6.40	1.55	1.05
32	G. P.	50	51	Confusional insanity	Broncho - pneumonia, hypothyroidism	51.0	1,055	0.48	0.06	7.49	3.98	4.73	1.75	1.55
33	E. G.	51	53	Manic depressive insanity	Exhaustion of chronic dysentery	46.0	1,145	0.75	0.30	26.50	7.20	6.70	2.35	1.95
34	H. B.	53	53	Alcoholic dementia	Morbus cordis, arteriosclerosis	61.0	1,130	0.70	0.30	8.70	7.80	5.00	3.70	—
35	E. H.	42	57	Climacteric melancholia	Pulmonary tuberculosis, tuberculous ulceration of intestine, gangrene of lung	24.0	1,225	0.40	0.12	10.97	2.86	3.19	3.80	4.00
36	E. P.	56	58	General paralysis	Bronchitis, emphysema, hypostatic pneumonia, commencing cerebral tumour, general paralysis	61.0	1 020	0.75	0.22	8.25	8.72	5.90	1.45	—

37	A. M. S.	48	Dementia	49.0	1,160	0.65	0.25	23.75	9.20	3.75	2.50	2.70
38	H. R.	39	Recurrent mania	60.5	1,090	0.61	—	13.15	4.10	2.72	2.85	3.12
39	E. B.	57	Presenile dementia	39.0	1,105	0.57	0.09	12.85	4.80	4.50	1.90	1.95
40	E. A. W.	60	Acute mania	41.0	1,280	0.70	0.20	23.80	6.60	6.00	2.60	2.55
41	M. A. D.	44	Dementia	57.0	1,265	0.83	0.2	16.15	5.16	4.50	2.40	2.20
42	R. A. L.	62	Dementia	83.0	1,130	0.83	0.07	22.00	5.10	4.80	1.35	1.35
43	E. A. H.	44	Mania	40.0	1,140	0.80	0.10	13.00	5.00	6.20	2.50	1.65
44	C. H.	43	Dementia	38.0	1,000	0.70	0.10	6.90	5.70	5.20	—	—
45	A. J.	57	Melancholia (alcoholic?)	57.0	1,160	1.20	0.07	12.60	4.95	4.65	1.40	—
46	E. N.	47	Melancholia	74.0	1,335	0.40	0.28	12.50	3.10	2.80	4.20	3.80
47	E. G.	68	Senile melancholia	37.0	1,265	0.65	0.42	22.25	5.95	5.35	1.65	—
48	E. W.	54	Melancholia	46.0	1,115	0.70	0.20	4.50	7.00	5.40	2.00	1.70

TABLE II—(continued).

No.	Name	Age on admission	Age at death	Disease	Cause of death and complications	WEIGHT								
						Body	Brain	Pituitary body	Pineal gland	Thyroid	Adrenals		Ovaries	
											Right	Left	Right	Left
49	E. H.	49	69	General paralysis	Purulent bronchitis, fatty heart, chronic Bright's disease	73.0	1,025	0.72	0.17	36.27	—	—	—	—
50	A. A.	49	70	Chronic mania	Pneumonia, pneumococcal meningitis	53.0	1,285	0.90	—	16.8	6.50	7.20	2.10	1.40
51	A. H.	70	72	Senile dementia	Cardiac failure	54.0	1,085	0.75	0.15	9.50	3.50	4.10	1.30	1.10
52	A. A.	72	74	Senile dementia	Bronchitis, bronchopneumonia, pachymeningitis hæmorrhagica	57.0	1,285	0.75	0.25	10.75	7.25	5.65	2.55	6.25
53	A. H.	71	75	Dementia secondary to melancholia	Arterio-sclerosis, chronic Bright's disease, atrophic emphysema	59.0	1,315	0.73	0.28	27.90	7.80	6.50	1.10	1.99
54	E. R.	73	75	Hypochondriacal melancholia	Subacute dysentery, fatty heart, bronchitis, emphysema, senile decay	43.0	1,205	0.60	0.20	9.50	4.60	5.10	0.80	0.81
55	J. B.	76	78	Senile mania	Subacute dysentery, senile decay, bronchitis	51.5	1,080	0.39	0.29	22.75	5.99	6.19	1.29	1.89
56	E. E. W.	60	81	Melancholia	Broncho - pneumonia, senile decay, advanced arterio-sclerosis	38.0	1,160	0.63	0.21	12.32	3.24	4.12	3.23	2.25
57	M. C.	65	82	Senile melancholia	Bronchitis, emphysema, heart failure, senile decay, granular contracted kidney	44.0	1,150	0.70	0.57	10.40	3.95	4.10	2.20	1.90
58	E. P.	79	83	Senile dementia	Broncho - pneumonia, senile decay	41.0	1,245	0.80	0.25	12.70	4.25	4.15	2.00	2.20
59	S. A. T.	77	84	Dementia	Subacute dysentery, senile decay, arterio-sclerosis	53.0	1,010	0.40	0.16	10.40	8.20	5.30	1.00	1.70
60	E. B.	76	88	Chronic mania	Senile decay, bronchopneumonia	34.0	—	—	0.30	18.40	7.65	3.60	2.10	1.65

TABLE III.—AVERAGE WEIGHT OF FIFTY MALE CASES.

Age-period	Thyroid			Pituitary body	Pineal gland	Adrenals		Testicles		Body	Brain
	Maximum	Minimum	Average			Right	Left	Right	Left		
30-39 (5 cases)	20.1	11.7	16.84	0.584	0.214	7.17	6.464	11.844	10.64	47.8	1315.0
30-39 (9 cases)	35.25	6.72	17.86	0.637	0.197	7.23	7.38	11.57	10.88	53.8	1365.0
40-49 (11 cases)	30.50	11.60	18.91	0.594	0.214	6.59	6.66	13.28	11.69	56.05	1415.2
50-59 (11 cases)	32.17	4.4	15.82	0.569	0.163	6.85	6.084	12.979	13.5	50.05	1327.09
60-69 (12 cases)	27.7	8.65	13.77	0.448	0.143	5.35	6.03	10.105	13.68	53.7	1198.7
70-79 (2 cases)	17.18	11.7	14.44	0.59	0.12	6.44	7.21	14.68	13.9	65.0	1245.0
80-70 (50 cases)	35.25	4.4	16.46	0.56	0.167	6.551	6.22	11.91	12.91	53.2	1308.6

TABLE IV.—AVERAGE WEIGHT OF SIXTY FEMALE CASES.

Age-period	Thyroid			Pituitary body	Pineal gland	Adrenals		Ovaries		Body	Brain
	Maximum	Minimum	Average			Right	Left	Right	Left		
19 (1 case)	—	—	20.50	0.62	0.25	8.00	8.7	4.2	5.9	51.0	1230.0
20-29 (4 cases)	27.85	9.8	17.3	0.61	0.13	6.26	5.91	2.37	2.69	44.3	1148.8
30-39 (9 cases)	51.20	7.7	18.23	0.69	0.2	6.01	4.7	3.68	4.8	47.1	1172.5
40-49 (17 cases)	52.52	9.2	18.55	0.59	0.14	6.14	5.98	3.81	3.17	46.4	1202.8
50-59 (8 cases)	26.5	7.49	13.95	0.61	0.19	6.08	4.56	2.53	2.54	48.9	1116.0
60-69 (10 cases)	36.27	4.50	16.99	0.753	0.171	4.856	4.49	1.81	1.325	54.6	1171.5
70-79 (5 cases)	22.75	9.5	16.2	0.68	0.23	5.94	5.79	1.52	2.24	52.9	1200.8
80-80 (5 cases)	18.4	10.4	13.84	0.63	0.39	5.45	4.25	2.1	1.34	42.0	1141.2
19-80 (60 cases)	52.52	4.5	16.87	0.652	0.198	5.81	5.2	2.62	2.97	48.04	1173.2

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According to Boyce and Beadles, the average weight is 0.453 gm. in the male and 0.6 gm. in the female. These observers investigated the weights in fifty cases of each sex dying in Colney Hatch Asylum. According to Schonemann, the weight of the pituitary body increases from birth to 10 years of age. At 20 years of age it is 0.54 gm., at 30, 0.8 gm., and from 20 to 30, 0.63 gm., while at the age of 50 it is 0.6 gm. Benda gave the weight as 0.5 to 1.0 gm., and he has concluded that under and over these limits it may be considered as evidence of hypo- or hyper-plasia associated with histological changes. An investigation carried out by Dr. Candler at Dr. Mott's suggestion gave the average weight as 0.469 gm. in eighteen males, and 0.567 gm. in twenty-six females. As Boyce and Beadles have pointed out, it seems that the average weight in the male is, in general, less than in the female, but there are, of course, many exceptional cases.

The average weight of the pineal gland is 0.167 gm. in the male and 0.198 gm. in the female. There is no difference corresponding to any particular disease. All the post-mortems were conducted on adults over 20 years of age, and therefore the variations in weight do not come into account. The largest gland found in the male was 0.5 gm., and in the female 0.57 gm. The smallest in the male was 0.03 gm., and in the female 0.05 gm. In a female with chronic mania, aged 70, the gland was absent.

The weight and condition of the adrenals depend upon many factors—for example, the cause of death, the duration of illness causing death, and the time elapsing before the post-mortem is made—that it is difficult to draw any conclusions regarding the comparative weight of these organs, but it is interesting to note that the weight of the right gland in thirty-eight cases of sixty females was heavier than the left. Elliott gives the weight of an adult male as 4 gm. to 5 gm. Testut gives 6 gm. to 7 gm. as the average weight of each adrenal. According to v. Neusser and Wiesel the weight is 11.6 gm. in the male and 10.6 gm. in the female. Parhon and Zugraw showed that it is less heavy in the female sex in the insane. My cases also show that the average weight in the female is less than in the male. There is no definite correlation between body-weight and weight of adrenal glands.

It is very difficult to draw conclusions regarding the weight of the testicles and the ovaries. Generally speaking, the ovaries reach a fairly heavy weight between the age-period 30 to 50 years. But in two cases of females, aged 28 and 25, the ovaries were small—e.g., the left ovaries were 1.75 gm. and 1.6 gm., while the right were 3.05 gm.



and 2.95 grm. respectively. In a case of dementia præcox, aged 33, who died after a few days' illness from broncho-pneumonia, the ovaries were also small, so that the right ovary was 1.8 grm., while the left was 2.7 grm. The weight of the testicles showed no difference according to the age. The weight varies considerably, so that the weight of the right testicle varies from 4.3 grm. to 24.75 grm. and that of the left from 4.1 grm. to 27.55 grm. In certain cases the testicles were comparatively small.

Case	Age		Right testicle		Left testicle
General paralysis ...	25	...	6.52	...	6.42
Tabo-paralysis ...	39	...	8.2	...	9.3
Manic depressive insanity ...	34	...	7.6	...	9.5
Recurrent mania ...	48	...	6.25	...	4.42
Melancholia ...	55	...	Castrated for tubercular epididymitis two years before onset		6.1

#### COMPARATIVE RESULTS AND INFLUENCE.

It may be inferred from the above statement that the thyroid gland in both male and female in the insane is generally smaller than the normal, but it will be noted that there are considerable variations in the weights of the thyroid glands, especially is this noticeable among the female cases that died just about the climacterium or before or after that period of life.

#### MALES WITH HYPOTHYROIDISM.

In six male cases and in eleven female cases the weight of the thyroid gland was under 10 grm. In a male patient with congenital imbecility, aged 51, all the glands were small, the thyroid weighing 4.4 grm. only. In certain male cases a correlation seems to exist between the weights of the glands, so that all the glands are small.

Case	Age	Pituitary body	Pineal gland	Thyroid	Suprarenals		Testicles	
					Right	Left	Right	Left
Tabo-paralysis...	39	0.34	0.05	6.72	5.72	8.22	8.2	9.3
Congenital imbecility ...	51	0.5	0.1	4.4	3.05	3.5	4.3	4.1
Melancholia ...	55	0.38	0.1	8.9	3.9	2.8	—	6.1
Katatonic ecstasy of dementia præcox ...	54	0.61	0.31	6.6	3.81	3.51	10.3	10.7
Recurrent mania ...	39	0.6	0.17	9.52	8.22	7.02	10.77	11.48

There are many conditions which need not be detailed that may exist to account for such differences of weight as occur; consequently it is not permissible with so few cases to draw any conclusions from the above.

## FEMALES WITH HYPOTHYROIDISM.

In certain female cases the thyroid gland and the ovaries were small; on the contrary, the pituitary body and the pineal gland were large. It seems, therefore, that there is a functional correlation between these glands:—

Case	Age	Pituitary body	Pineal gland	Thyroid	Suprarenals		Ovaries	
					Right	Left	Right	Left
Primary dementia ...	26	0·6	0·1	9·8	3·2	2·8	2·9	2·4
Confusional insanity ...	44	0·77	0·12	9·2	4·25	4·55	1·2	1·6
Mania ...	48	0·77	0·07	9·27	7·77	13·57	1·7	1·7
Post-hemiplegic dementia (general paralysis) ...	58	0·75	0·22	8·25	8·72	5·90	1·45	—
Alcoholic dementia ...	53	0·7	0·30	8·70	7·80	5·00	3·70	—
Senile dementia ...	72	0·75	0·15	9·5	3·5	4·1	1·3	1·1
Hypochondriacal melan- cholia ...	75	0·6	0·2	9·5	4·6	5·1	0·8	0·81

In the subjoined two female cases, which I will describe later as hypothyroidism, the pituitary bodies were very large.

Case	Age	Pituitary body	Pineal gland	Thyroid	Suprarenals		Ovaries	
					Right	Left	Right	Left
Confusional insanity ...	47	1·05	0·25	33·6	5·08	5·25	3·35	Cystic
Melancholia (alcoholic?)	67	1·20	0·07	12·6	4·95	4·65	1·4	—

Parhon showed that the average weight of the thyroid of the insane is greatest in the affective psychoses—i.e., mania, melancholia, mania depressiva—and least in epilepsy. In my cases there is no definite relation between the weight and the affective psychosis in the male. In thirteen female cases the thyroid glands were over 20 grm. These cases are as follows: Adolescent mania, one case; insanity of adolescence, one case; melancholia, three cases; mania, five cases; dementia, two cases; confusional insanity, one case. It seems difficult to confirm the conclusion of Parhon, but it is noteworthy that the thyroid gland in many female cases of the affective psychoses is large.

In the subjoined female case of dementia præcox, aged 33, who died from broncho-pneumonia after a few days' illness, all the glands were comparatively smaller than the average.

Case	Age	Pituitary body	Pineal gland	Thyroid	Suprarenals		Ovaries	
					Right	Left	Right	Left
Dementia præcox ..	33	0·4	0·15	7·7	2·8	3·4	1·8	2·7

The weight of the pituitary gland has no definite relation to the nutrition of the body, to the form and the duration of the insanity, or to

the nature of the other organic diseases which were met with at the autopsy, except in the cases of hypothyroidism.

The differences in weight of the glands previously described seem to indicate that there may be an interference with the normal metabolism of the ductless glands in the cases recorded. It is possible, therefore, that the mental condition may in some way be associated more or less with a deranged function of the ductless glands interfering with the normal bio-chemical equilibrium of the hormones.

#### CONCLUSIONS REGARDING THE WEIGHT OF THE DUCTLESS GLANDS IN THE INSANE.

(1) The average weight of the thyroid gland in both male and female subjects of insanity is generally smaller than the normal. Thus the average weight is 16.46 gm. in the male and 16.87 gm. in the female; in 12 per cent. of the male and 18 per cent. of the female the thyroid glands were under 10 gm. There are considerable variations in the weight, especially among the female cases at the climacterium or shortly before and after that period. In many female cases of affective psychosis the thyroid gland was very large.

(2) The weights of the external parathyroid glands vary from 0.01 gm. to 0.07 gm. In 21.9 per cent. of the cases four glands were found.

(3) The average weight of the pituitary body is 0.56 gm. in the male and 0.62 gm. in the female. In the female cases in which the thyroid glands were small the pituitary body was generally large. The weight has no definite relation to the nutrition of the body, to the form and the duration of the insanity, or to the nature of the other organic diseases, except in certain cases of hypothyroidism.

(4) The average weight of the pineal gland of the adult is 0.167 gm. in the male and 0.198 gm. in the female. There is no difference corresponding to any particular disease.

(5) The adrenals of the male are, generally speaking, heavier than in the female. There is no definite correlation between body-weight and weight of these glands.

(6) No definite conclusion can be arrived at regarding the weight of the reproductive glands in the male and female in relation to body-weight or mental disease, but in certain female cases, in which the thyroid gland was small, the ovaries were also remarkably small.

## PART II.

### THE HISTOLOGICAL EXAMINATION OF THE THYROID GLAND AND OTHER DUCTLESS GLANDS.

As already mentioned, in six male and in eleven female cases the thyroid glands were under 10 grm. In two cases out of the above eleven females marked fibrotic changes of the glands were seen by microscopic examination. Moreover, in two other female cases of confusional insanity and of melancholia (alcoholic?) the thyroid glands were 33.6 grm. and 12.6 grm. respectively. Microscopic examination exhibited a marked increase of the fibrous tissue and an atrophy of the gland structure. These two cases may also be regarded as hypo-function of the thyroid—viz., hypothyroidism. As above mentioned, in four female cases of hypothyroidism it was found that the thyroid glands showed evidence of morbid changes under the microscope. In three cases, in addition to the fibrous hyperplasia there was a marked lymphoid infiltration. This subject of hypothyroidism will now be dealt with, combined with a description of the other ductless glands.

### THE MATERIAL.

All the materials were preserved in formalin—Müller's, Flemming's, or Zenker's fluid. Some preparations from the thyroid gland embedded in celloidin were stained with hæmatoxylin-eosin and by Van Gieson's method. The preparations from other glands, embedded in paraffin or celloidin, were also stained with hæmatoxylin-eosin, Van Gieson's and Heidenhain's eosin staining fluids. The frozen sections of the adrenals were stained with Scharlach, Sudan III, or the same combined with hæmatoxylin.

### CASE I.

#### *Clinical Notes.*

M. T. A., aged 47, widow; former occupation a cook. First attack. Admitted to Claybury Asylum on August 10, 1914. Died on December 30, 1914.

According to the certificates, she is rambling about people talking to her and calling her on the telephone. She imagines that she has electricity about her; delusions that people are watching her in her room and from the houses opposite. She answers imaginary voices, and has telephone messages to go to

different places. She imagines also that she has electricity at the back of her head, and thinks her bed is electrified. Her son says she has suffered with delusions for about a week; she imagines people are talking to her from the windows opposite, that telephone wires run through the room to the house opposite, and messages are sent through it. She has an idea that people have put a spell on her, and that she might be poisoned.

State on admission: Fair physique, good nutrition. Lungs normal. Heart's action irregular; pulse 90. Mental condition: She is very noisy and excitable, raving and shouting; rambling and incoherent. She believes she is being electrified. She has visual and aural hallucinations. Hands are broad and spade-like. Face is swollen and pasty, but not œdematous. Her condition suggests a case of myxœdema.

Progress of case, August 17, 1914: She is suffering from confusional insanity; myxœdema. She is *deliberate and slow in response to questions*. Rather restless, very rambling. She has no correct knowledge of time or place, and has hallucinations of sight and hearing. She believes she is strapped down to the electric light, and that she is here to be ill-used and have her circulation and breathing stopped. She has visceral sensory disturbances. She is continually chattering to herself in an incoherent manner. She does not know whether to take her own life or not. Well nourished, but in greatly impaired health.

The patient did not improve, retained her persecutory delusions, and on December 28, 1914, commenced to have seizures. Pupils reacted sluggishly to light and accommodation, and several notes indicate that during the later period of her life she was becoming demented, for she was said to be suffering with general paralysis. She died on December 30, 1914, from bronchitis and emphysema of both lungs.

*Autopsy (made by Dr. Mott).*

A female, fair physique, body well nourished, little puffiness about the eyelids, no bruises or bed-sores. Linea alba on abdomen. No enlargement of hands or feet. Hair is thin. General appearance is suggestive of hypothyroidism. No external marks of syphilis.

The skull is normal in appearance. Dura mater and pia-arachnoid are not thickened. Stripping of pia-arachnoid without erosion in a normal manner. In the subarachnoid space no excess of fluid. Encephalon is normal in appearance. Convolutions exhibit a somewhat simple pattern. No local softening, not much general wasting. Very slight superficial hæmorrhage on the surface of the pons. *No granulations in the fourth ventricle.* The pituitary body is remarkably larger than the normal; weighed 1.05 gm., reddish. It stands out a little from the sella turcica. The pineal gland is pink and fairly large; weighed 0.25 gm.

Larynx shows marked œdema of the tissue forming the glottis and epiglottis. The thyroid gland is very pale, fibrous, and compact; weighed 33.6 gm. The external parathyroid glands are four in number, of irregular

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oblong shape, fairly large, 0.05 grm. to 0.06 grm. Bronchi contain frothy mucous fluid and are congested. Right pleura: No adhesions, no fluid. Left pleura: Slight adhesion at apex, no fluid. Right lung emphysematous, all parts crepitate, congested, œdematous; the left same as the right.

Small bronchi are congested, filled with frothy mucous fluid. Heart muscle is firm, but fairly easily lacerated by the finger-nail. The ventricles are contracted, firm, do not collapse. Atheroma of first degree in arch of aorta more marked in the descending branch.

The liver congested, rather fatty on section. The right kidney: The capsule thickened, somewhat adherent, strips leaving a slightly granular surface. Excessive fat in the pelvis. The left kidney same as the right. The right adrenal is smaller than natural, 5.08 grm., normal on section; the left also normal, 5.25 grm. Abdominal aorta shows a little atheroma. The right ovary is of the size of a cricket ball; section shows this to be due to a dermoid cyst; the left is fibrotic, the surface is corrugated, 3.35 grm. The Wassermann reaction of the serum and of the cerebrospinal fluid was negative.

*Cause of Death and other Pathological Conditions.*—Œdema glottidis bronchitis, emphysema of both lungs, hypothyroidism, myxœdema.

### *Microscopical Examination.*

(1) *The Thyroid Gland.*—The vesicular structure of the gland is almost entirely replaced by dense connective tissue, in which marked lymphocyte infiltration is seen, here and there, forming islets of cells. The lymphoid cell masses vary in size and form. In this mass the remnants of the atrophied vesicles are scattered. The epithelial cells of the vesicles have undergone hyaline degeneration. Some few of the remnants of the vesicles contain colloid, which is stained by eosin and picric acid (hæmatoxylin—Van Gieson); other atrophied vesicles contain only disintegrated epithelial cells. Under a high power the fibres of the connective tissue appear swollen and thickened. The epithelial cells have a degenerated hyaline homogeneous appearance. Some slight thickening of the wall of the blood-vessels is also observed (see Plate, figs. 1, 2, 3, and fig. 5).

(2) *The Parathyroid Glands.*—In the middle of the section, forming the glandular structure, comparatively abundant principal cells are seen; near the periphery they decrease in number. The converse is the case with the oxyphile cells (Welsh). The capillaries are dilated and sinus-like. Some follicles contain colloidal drops, which are stained with eosin; in the lumen of some follicles can be seen the detritus of the cells.

(3) *The Pituitary Body.*—Some capillaries are remarkably dilated like a sinus, accompanied by thickened connective tissue. The *pars intermedia* is enlarged, and a few large cystic vesicles are seen, and excess of colloid. Throughout the whole section of the glandular portion, especially in the hind-part and near the periphery, are many cyanophile cells which vary in size; in the other part they are either scattered or in groups. There are many





FIG. 1.

Thyroid gland (Case I), Van Gieson haematoxylin, showing increase of connective tissue and lymphoid cell infiltration. The remnants of the gland containing colloid are seen. ( $\times 80$ .)

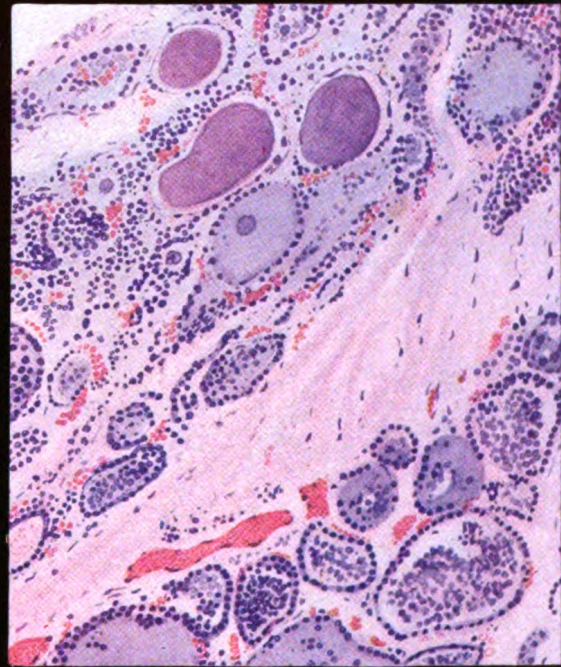


FIG. 4.

Thyroid gland (Case IV), haematoxylin-eosin, showing an increase of connective tissue, marked congestion and slight lymphoid infiltration around the vesicles. Débris of epithelium in the vesicles are also seen. Colloid shows a micro-chemical change. ( $\times 160$ .)

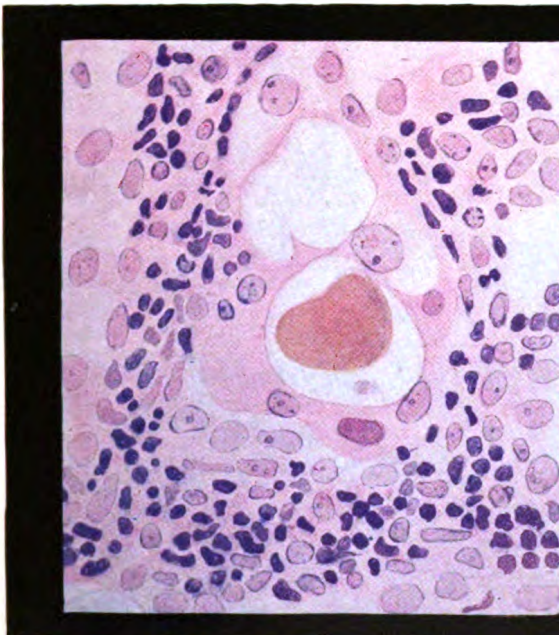


FIG. 2.

Same as fig. 1, showing hyaline degeneration of epithelial cells of the vesicles containing colloid. Lymphocytes and debris of epithelium are also seen. ( $\times 330$ .)



FIG. 3.

Same as fig. 1, showing degeneration of epithelium of vesicle containing colloid. ( $\times 750$ .)

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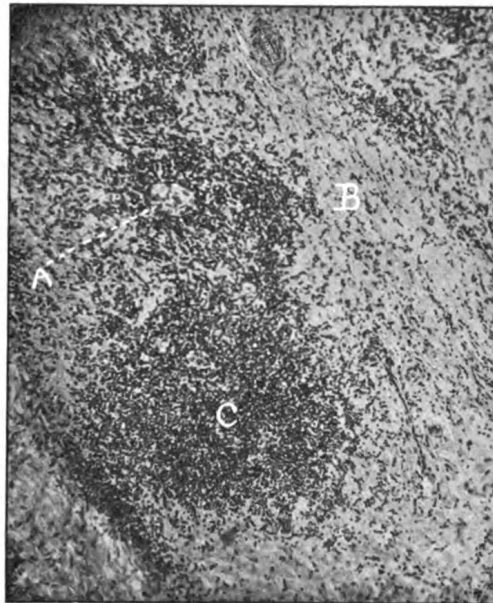


FIG. 5.

Thyroid gland (Case I), hæmatoxylin-eosin. The colloid-containing vesicles have almost disappeared, only a few remnants (A) of the gland structure being left. Replacement of the glandular tissue by fibrous (B) and lymphoid tissue (C) has occurred. ( $\times 90$ .)

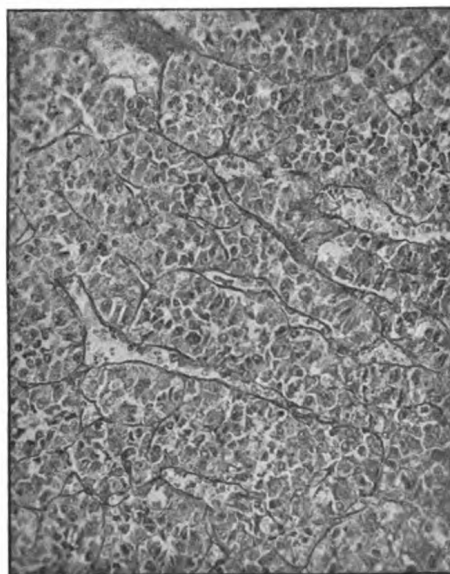


FIG. 6.

Parathyroid gland (Case I), hæmatoxylin-eosin, showing abundant principal cells forming glandular structure. ( $\times 200$ .)

eosinophile cells, especially in the hind-part of the glandular portion. The principal cells are in fair number; their protoplasm is scanty, clear, or slightly stained with eosin. The lumen of some follicles contain colloid as a drop, stained dark red. A few lymphocytes are scattered in the interstitial tissue of the *pars intermedia*. Some of the cyanophile cells contain a homogeneous clear substance. Generally speaking, both the eosinophile and cyanophile cells are remarkably increased in number in proportion to the principal cells. The posterior portion (*pars nervosa*) appears to show no special changes.

(4) *The Pineal Gland*.—In the middle of the gland is a large fibrotic patch containing a large cyst with a thick fibrotic wall. In the hind-part of the gland there is also a large cyst. In the remaining parts are numerous alveoli, of various sizes, separated from each other by septa of concentric bodies consisting of connective tissue. Near the periphery of the gland earthy salts are seen, which vary in size and shape, stained dark red with hæmatoxylin-eosin. The cysts contain serous fluid with many disintegrated cells.

(5) *The Adrenals*.—The cortex and medullary portions are intact. The lipoid substance is generally diminished in the cells of the cortex. Some of the cells, especially in the zona glomerulosa, contain no lipoid.

(6) *The Ovary*.—The left ovary is fibrous; there are no follicles, and the gland presents the appearance of complete involution. There are seen here and there in the section many small old corpora albicantia and three large old *corpora lutea*, scattered around which are lutein cells.

*Résumé*.—The thyroid gland shows the most advanced atrophic change with increased connective tissue and considerable accumulation of lymphoid cells. All the epithelial cells have undergone hyaline degeneration, destroying the proper function of the gland. Generally speaking, the thyroid gland shows a pseudo-hypertrophy. The accumulation of the lymphocytes and fibrous tissue suggests a chronic inflammatory change, possibly of toxic origin.

## CASE II.

### *Clinical Notes.*

E. M. E., aged 44, married, housewife. Admitted to Claybury Asylum on November 19, 1914, from Tooting Bec Asylum, where she had been since November 17, 1914. First attack. Died on December 30, 1914.

According to the certificates she imagines that she is in Kentish Town Hospital, and that she has just arrived. She imagines also that some women are playing tricks on her, and trying to take her husband from her; she has no idea where she was living. She is restless and noisy. She thinks that all her food is poisoned, and she is subject to outbursts of acute excitement, when she is very violent.

State on admission: Fair physique, nutrition poor. Scattered rhonchi in both lungs. Heart and pulse normal. Pupil reflexes are also normal. Knee-jerks are present. Mental condition: Reaction time is increased. She

is unable to answer simple questions. She thinks that the nurse is named "Lizzie" or "Mrs. Knight," and that this is the "Hospital for Cats." Habits dirty. Noisy and abusive at times.

Progress of case (November 26, 1914): She is suffering from confusional insanity, alcoholic (?). She is lost and wandering, making incoherent statements as to a baby being with her in bed and being then stolen. She thinks that she is in the Asylum tavern, Caterham; also that she is in the Council schools, where she has been for some weeks. No idea of time or place; confuses individuals, whom she addresses familiarly. General habits and condition are poor. Feeble and shaky. Looks ill and pallid. Knee-jerks are normal; no pains in legs, but unable to walk without support.

She gradually sank and died from broncho-pneumonia on December 30, 1914.

*Autopsy (made by Dr. Mott).*

A female, rather emaciated, teeth in upper jaw deficient, palate high and narrow. Linea alba over abdomen and thighs. Over each knee a fibrous growth the size of a walnut.

The skull is normal in appearance. Beneath the scalp is a considerable hæmorrhage which extends beneath the pericranium and appears to be recent. No sign of fracture of calvarium. Pia-arachnoid is opalescent, thickened, pale, stripping fairly readily. The convolutions of the encephalon are rather simple; there is some general wasting, especially of fronto-central regions. No local softening. Striations of the cortex are indistinct. No granulation in the fourth ventricle. Lateral ventricles are dilated. The pituitary body is slightly reddish, rather large, 0.77 gm. The pineal gland is also rather large, 0.12 gm.

The larynx contains a quantity of blood and mucus. The thyroid gland is small, compact, 9.2 gm. There were two external parathyroid glands on both sides. Thorax: Cartilages are not ossified. Pleura: No fluid, no adhesions. The bronchi contains blood-stained mucus. Both lungs show emphysema and broncho-pneumonia. Heart, *nil*, abnormal. Aorta shows early arterio-sclerosis.

The liver very congested, marked by corset. The spleen is enlarged and congested. The right kidney is small, excess of fat is present in the pelvis; the capsule strips leaving a slightly granular surface with cysts. The left kidney shows nothing special. The right adrenal is firm, good colour, 4.25 gm.; the left the same, 4.55 gm. The abdominal aorta shows a few slight nodular enlargements. Throughout the large intestine is seen a thickening of the mucous membrane, but no ulcerations.

The left ovary is bound to uterus by firm adhesions, weight 1.6 gm.; the right also, but less markedly so, weight 1.2 gm. The Wassermann reaction of the cerebrospinal fluid was negative.

*Cause of Death and other Pathological Conditions.*—Broncho-pneumonia, hypothyroidism, old parametritis, old salpingitis of both sides, grave anæmia.

*Microscopical Examination.*

(1) *The Thyroid Gland.*—The sections of the several parts show that the gland is divided into many different-sized lobules by dense connective tissue septa. Each lobule is also subdivided into small portions by thickened connective tissue. The gland structure shows, in general, atrophy, and the vesicles vary in size considerably. The vesicles are remarkably diminished in size. Some vesicles show a papillomatous change, and the epithelial cells are, in general, cubical; the nuclei are nearly round, containing uniform fine granules. But in some vesicles the epithelial lining is remarkably flattened,

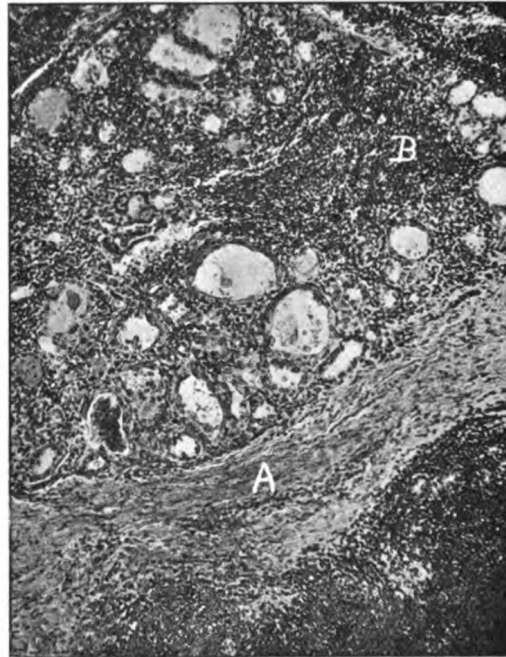


FIG. 7.

Thyroid gland (Case II), hæmatoxylin-eosin, showing an increase of fibrous tissue (A) and lymphoid infiltration (B), with a corresponding atrophy of the vesicles, which vary in size. The epithelial cells are flattened; some of them under a higher magnification show commencing degeneration. ( $\times 90$ .)

and the nuclei are long and narrow, and surrounded by scanty cytoplasm. A few epithelial cells show fine eosinophile granules in the cytoplasm. Around the vesicles there are accumulations of lymphocytes. Some portions of the fluid consist almost entirely of lymphocytes, in which small vesicles are here and there scattered. Some vesicles contain colloid, stained feebly or deeply with eosin. The smaller vesicles are often filled with desquamating epithelial cells. Some slight thickening of blood-vessels is seen (*see fig. 7*).

(2) *The Parathyroid Glands*.—Abundant principal cells are seen in the middle and margin of the gland. Many oxyphile cells are also seen as strands, or scattered throughout the section. Many of the follicles contain colloid, stained deeply with eosin.

(3) *The Pituitary Body*.—In the *pars intermedia* many large vesicles are seen: it contains colloid, stained with eosin. The *pars nervosa* appears to show no special changes. Certain follicles of the glandular portion are dilated and filled with colloid, stained deeply with eosin. The eosinophile cells are abundant in number in the middle and in the neighbourhood of the *pars intermedia*. In general, the cyanophile cells are increased and have a contrary arrangement to the eosinophile cells. Nearly all the follicles in the anterior

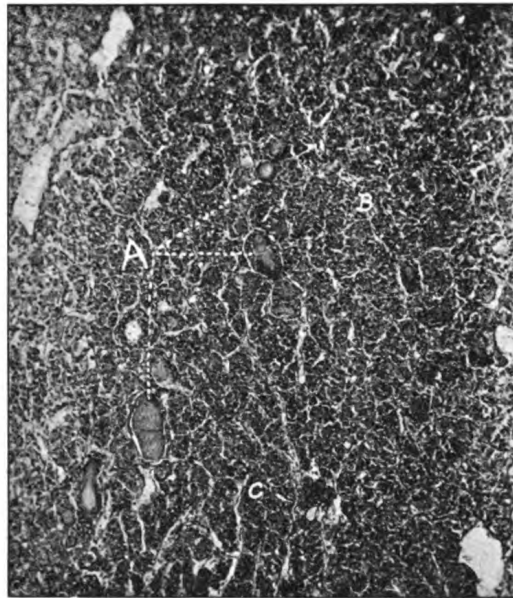


FIG. 8.

Pituitary body (Case II), hæmatoxylin-eosin, showing an enlargement of the follicles (A) containing colloid. Abundant eosinophile (B) and cyanophile (C) cells are also seen. ( $\times 90$ .)

part of the glandular portion are composed of cyanophile cells only; but in other parts of the gland the two kinds of cells and the principal cells are seen in the follicles. The principal cells are fairly numerous in number (*see fig. 8*).

(4) *The Pineal Gland*.—The section shows a complete involution of the gland and contains many masses of brain-sand, which vary in size and shape, as in Case I. There is also an increase of connective tissue, even more than in Case I.

(5) *The Adrenals*.—The cortex is stained unevenly with Scharlach. Some groups of the cortex cells are stained feebly; on the other hand, there are

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deeply stained groups of cells. In general, the lipoid substance is considerably diminished.

(6) *The Ovaries*.—Both ovaries are, generally speaking, fibrotic. There are a few corpora albicantia and two small corpora lutea. Neither lutein cells nor follicles are seen. The appearances suggest an early complete involution.

*Résumé*.—The thyroid gland shows atrophy of the glandular substance associated with the appearances of a chronic inflammatory change in the interstitial tissue, as shown by the lymphocytic proliferation and fibrosis. As in Case I, the pituitary was enlarged, and an excess of colloid shown.

### CASE III.

#### *Clinical Notes.*

A. J., aged 67, married, housewife, former occupation a dancer. Admitted to Claybury Asylum on June 8, 1906. The age on first attack was 58. Died on January 15, 1915.

According to the certificates she says a baby has been killed and that she is going to be hanged for it. She also fancies that other inmates are continually interfering with her, and that the nurse has been putting poison in her tea. She imagines that the people are calling out to her and answers them. She is troublesome and keeps undressing herself, fancying there are rats about her.

State on admission: Venues on face. Tremor of tongue. Heart is not enlarged; systolic sound at apex conducted outwards. Pulse is regular. Pupils are equal, resist sluggishly to light. Knee-jerks are present. Mental condition: She speaks slowly and indistinctly. Marked tremor of face, hands and tongue. Her memory is poor; no idea of time and place. Lost and confused; very emotional.

Progress of case (June 14, 1906): She is suffering from melancholia, alcoholic (?) Her memory is greatly impaired. She thinks that she is in a music-hall, and that to-day is March 10. Speech tremulous; difficult to understand. Tremor of facial muscles during speech. Wanders aimlessly about. Very depressed, mind weakened. Poor health and condition. Right pupil is slightly larger than the left, and reaction to light uncertain. Knee-jerks are present.

May 5, 1907: She is suffering from dementia (alcoholic? paralytica?). Slight general impairment of the higher mental faculties, especially those of understanding and reason, in particular in regard to her present relationships to her environment, and a weakening of the memory. Conduct good; works well under supervision. No special propensity to forgetfulness. Sanguine, even optimistic about herself. Fair health and condition. Fairly well marked tremors of lips and tongue. Pupils equal, they react to light, but sluggishly to accommodation. Knee-jerks are somewhat exaggerated.

May 5, 1908: She is suffering from general paralysis of the insane. She

is facile and emotional. Her memory is impaired, and she asks the same questions day after day. At times cries for no obvious reason. Fair health and bodily condition.

She continued to be tremulous, and gradually became demented and more emotional and incoherent. On January 13, 1915, she appeared dazed and lost, and was put to bed. On January 14 she had a number of seizures, and died from acute bronchitis and emphysema on January 15, 1915.

*Autopsy (made by Dr. Mott).*

A female, well nourished, good physique. The hands are rather large and œdematous, also the feet. No œdema elsewhere. The face is rather puffy and œdematous.

The skull is thicker and denser than natural. The dura mater is adherent. The subdural space contains an excess of fluid, the subarachnoid space also an excess of fluid. Encephalon: The convolutions are rather simple in pattern. A little general wasting. No local softening. No erosions on stripping the pia-arachnoid. The white matter is œdematous. No signs of granulation in the fourth ventricle. The pituitary body is considerably enlarged, 1·2 gm., especially its anterior part. The *sella turcica* is very large and the posterior clinoid processes have been absorbed. The pineal gland is comparatively small, 0·07 gm.

The larynx and the trachea are congested. The thyroid gland is small, pale in colour, 12·6 gm. There are four parathyroid glands, two on each side. Both pleura are free from adhesions and fluid. Bronchi are very congested, extending to the smallest tube. Both lungs are congested and œdematous. The left lung is emphysematous. The heart shows hypertrophy of the left ventricle, of fair colour; no valvular disease. The aorta shows nothing special.

The liver is small, congested, fatty. The spleen is large and pulpy. Both kidneys *nil*. Both adrenals are disintegrated in the centre—the right weighed 4·95 gm., the left 4·65 gm. The right ovary is small, shrunken and hard, 1·4 gm.; the left is destroyed by very old adhesive salpingitis. The Wassermann reaction of the serum and of the cerebrospinal fluid was negative.

*Cause of Death and other Pathological Conditions.*—Acute bronchitis, emphysema, chronic Bright's disease, hypothyroidism, old adhesive salpingitis.

*Microscopical Examination.*

(1) *The Thyroid Gland.*—In general the sections show a marked hyperæmia and an increase of the intervesicular connective tissue. The vesicles contain colloid stained purple with hæmatoxylin-eosin, but most of them contain only débris of epithelium, stained dark blue by hæmatoxylin. The capillaries around the vesicles show marked congestion. Hæmorrhages are seen in certain parts. The epithelial cells are generally flattened; the nuclei are round, containing fine granules. A few epithelial cells contain fine eosinophile granules in the cytoplasm. There is slight lymphoid cell infiltration of the

interstitial tissue. There is a desquamation of the cell lining of the vesicles. In some of the vesicles, embedded in the ordinary colloid, there are several large circular bodies which are deeply stained with hæmatoxylin. They have no structure and appear to be colloidal in nature. The blood-vessels of the gland show slight thickening of the tunica intima (*see fig. 9*).

(2) *The Parathyroid Glands*.—The whole transection of the gland shows a number of hollow spaces which appear to be vesicles, similar in appearance to the fat vesicles of the exterior of the gland. Many sections also show patches of various degrees of coagulation necrosis of the epithelium. These necrotic cells exist in patches of variable size throughout the gland. In the

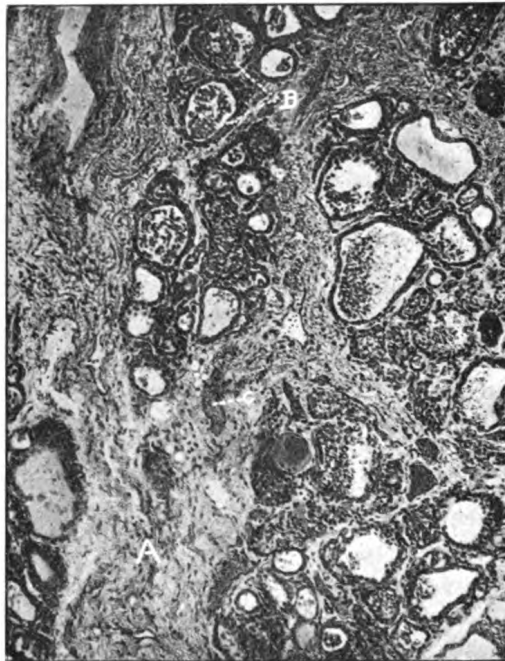


FIG. 9.

Thyroid gland (Case III), hæmatoxylin-eosin, showing a marked hyperæmia and an increase of the intervesicular connective tissue (A). Some vesicles contain colloid, or colloid mingled with debris of cells (B), and others are filled with debris of cells only (C). The colloid shows microchemical change, stained with eosin or hæmatoxylin. A blood-vessel is seen here and there. ( $\times 90$ .)

lumen of the follicle colloid is seen, here and there, in the section ; in one part there is a comparatively large cyst, filled with colloid, which is stained deeply with eosin. The whole section shows a marked increase of the oxyphile cells and a relatively less number of the principal cells. The right upper parathyroid gland contains more colloid than the other (*see fig. 10*).

(3) *The Pituitary Body*.—In general the glandular portion is enlarged, and



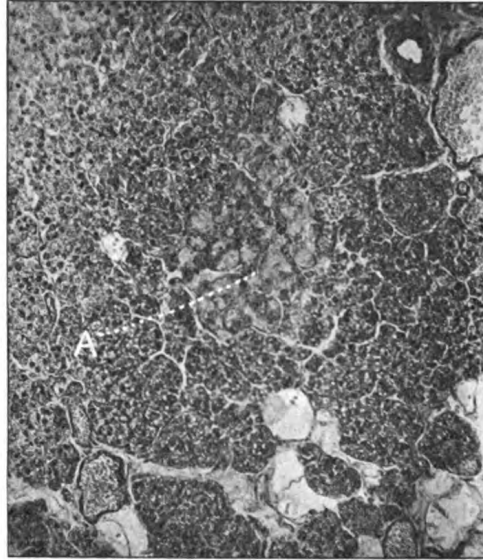


FIG. 10.

Parathyroid gland (Case III), hæmatoxylin-eosin. In the middle the patch of coagulation necrosis (A) is seen. Around the patch there are many oxyphile cells. ( $\times 90$ .)

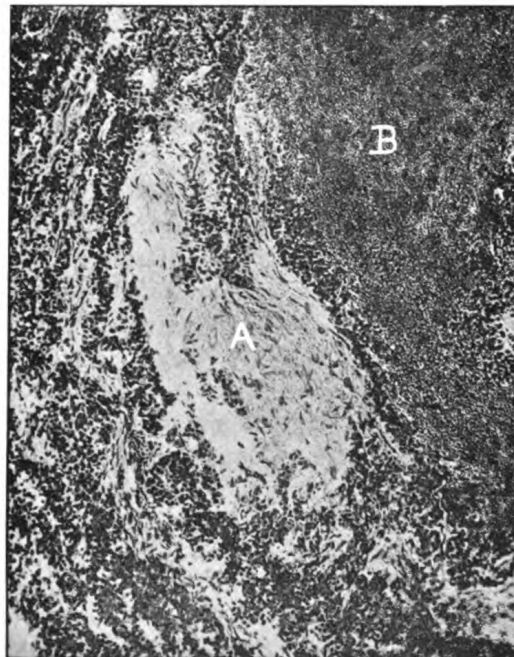


FIG. 11.

Pituitary body (Case III), hæmatoxylin-eosin, showing in the middle a patch of connective tissue (A), and on the right a hæmorrhagic patch (B) is seen. ( $\times 90$ .)

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the middle of it shows a fairly large patch of connective tissue. In the other parts the connective tissue is also increased. Close to the patch of connective tissue there is also a large hæmorrhagic patch, apparently of recent origin, which can be seen even by the naked eye. Around the hæmorrhagic patch there is a slight lymphoid cell infiltration. The other parts show a slight hyperæmia. Many follicles in the *pars anterior* are larger than usual and contain colloid. There are also abundant eosinophile cells, especially in the posterior part. The cyanophile cells are increased in number, and are seen most in the front part. The intermediate and the posterior portions are also very congested (*see* fig. 11). The *pars intermedia* did not show, as in Cases I and II, a marked increase of colloid.

(4) *The Pineal Gland*.—The whole section shows a marked thickening of the inter-lobular connective tissue. Otherwise there is no special change.

(5) *The Adrenals*.—The cortex sections show unevenly stained patches with Scharlach. Certain cortex cells are loaded with abundant lipoid, but most of them contain scanty lipoid.

The ovary on the right side is fibrous throughout, and shows advanced involution. Corpora albicantia are seen, but no lutein cells were observable.

*Résumé*.—The thyroid gland shows atrophy, with a much less degree of interstitial change than the two previous cases. The hyperæmia of the gland may be due to the acute bronchitis, and congestion of the lungs and other organs. With regard to the necrotic process of the cells of the parathyroid glands, it is difficult to come to any conclusion.

#### CASE IV.

##### *Clinical Notes.*

G. M. P., aged 51, married, housewife. Admitted to Claybury Asylum on December 10, 1914. First attack. Died on January 2, 1915.

According to the certificates she is confused. Her memory is poor. She imagines that other inmates of the ward are her relations. She calls to imaginary people in the ward to bring her beer. Her husband stated that she has been drinking heavily for some time.

State on admission: Fair physique, nutrition poor. Lungs are normal. Artery wall thickened. Pulse 72, collapsing type. Heart sounds at apex; first sound systolic murmur, second sound loud, late, diastolic murmur. The liver is hard, 2 in. below the costal margin. Urine shows a trace of albumin. Pupil reflexes are present. Knee-jerks are also present. Varicose veins of both legs. Mental condition: Mode of speech is slow. Reaction time is increased. She is unable to give an account of herself. Her memory is lost. She makes mistakes in identity. No delusions or hallucinations. Admits alcoholic excess.

Progress of case (December 17, 1914): She is suffering from confusional insanity. She is depressed, confused, and lost. She has no knowledge of

time and place. Slow to answer questions, dull, and complains of a giddy feeling. She makes imaginary journeys and thinks she came up to see me at the Southend Hospital yesterday, which is not the case. She is helpless and has defective habits. Poor general health and condition.

The patient gradually became worse and died on January 2, 1915, from broncho-pneumonia.

*Autopsy (made by Dr. Mott).*

Nutrition good. A flush on the cheeks, no venules on the nose. No bruises or bed-sores. The hands are not enlarged. Varicose veins. "The facial expression is somewhat suggestive of cachexia thyreopriva." No external marks of syphilis.

The dura mater is not adherent, no deposit. The subdural space contains no excess of fluid. The pia-arachnoid shows no marked thickening, not stripping readily. The subarachnoid space contains also no excess of fluid. The encephalon: The pattern is very simple, both frontal and parietal lobes being deficient suggests a high-grade imbecile. No local softenings or atrophy. The striation of the line of Gennari is quite distinct. The pituitary body is of normal colour, weighing 0.48 gm. The pineal gland is small, 0.06 gm.

The trachea is congested; the larynx shows post-mortem staining congestion. The thyroid gland is reddish, small, 7.49 gm. The parathyroid glands are two in number at both sides. All parts of the right lung crepitate; the lower lobe is congested and œdematous, the upper lobe is emphysematous and congested. The lower lobe of the left lung is solid, and shows well-marked patches of broncho-pneumonia; the upper lobe is emphysematous and congested. The heart muscle substance is of fairly good colour. No atheroma of aorta.

The liver is marked by tight lacing, firm, and suggests an early fibrosis, marked by fatty degeneration. The spleen is rather pulpy. Both kidneys are somewhat congested, the capsule is slightly adherent. Both adrenals are disintegrated, the right is 3.98 gm. and the left 4.73 gm. No evidence of salpingitis. Both ovaries are flattened, shrunk, and corrugated; the right weighed 1.75 gm., the left 1.55 gm. The Wassermann reaction of the serum and of the cerebrospinal fluid was negative.

*Cause of Death and other Pathological Conditions.*—Broncho-pneumonia, hypothyroidism.

*Microscopic Examination.*

(1) *The Thyroid Gland.*—The whole section shows an increase of connective tissue, marked congestion, but no lymphoid infiltration. The vesicles vary in shape and size, and contain colloid, which stains slightly or dark blue with hæmatoxylin, or purple with hæmatoxylin-eosin. The colloid is mingled, in many vesicles, with the detritus of the epithelial cells. The epithelial cells are cuboid in form; the nuclei are round, containing fine granules. The

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protoplasm of many cells contains fine eosinophile granules. In many of the colloid masses round spaces like a vacuole are present. Some vesicles are entirely filled with hyaline debris. A desquamation of the lining of the epithelial cell is seen in many vesicles (*see* Plate, fig. 4, and fig. 12).

(2) *The Parathyroid Glands.*—The right gland shows, in general, abundant principal cells, which are decreased in number at the periphery. The left shows, in general, a decrease of the principal cells and an increase of the oxyphile cells. The group of cells near the periphery of the left gland is composed chiefly of oxyphile cells. In a few follicles of the glands colloid is seen, stained bright red with eosin. In the left parathyroid gland fatty infiltration

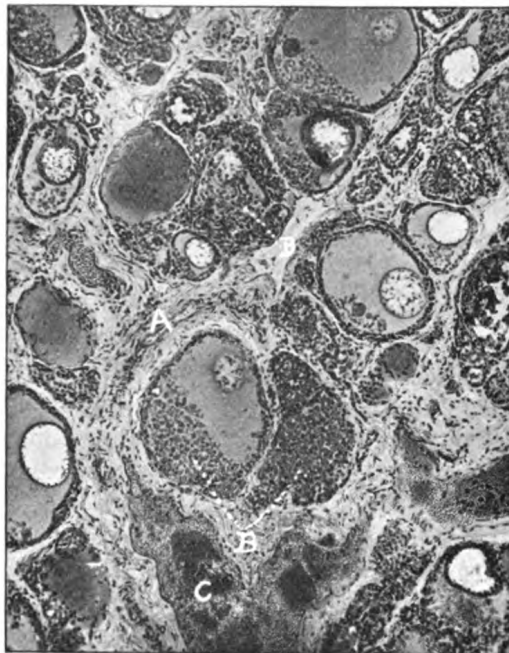


FIG. 12.

Thyroid gland (Case IV), haematoxylin-eosin, showing an increase of connective tissue (A), marked congestion, and slight lymphoid infiltration around the vesicles. Epithelial cells are flattened. The vesicles contain colloid, which shows microchemical change, mingled with debris of cells (B). A blood-vessel (C) is seen here and there. ( $\times 90$ .)

is seen, which extends inwards to the glandular mass, and like islands, separates the glandular structures in many parts. Near the periphery, and in some deeper portions of the gland, patches of the watery-clear cells (Getzowa) are here and there seen (*see* fig. 13).

(3) *The Pituitary Body.*—The infundibulum, the anterior, the posterior and the intermediate portions are very congested. Nearly all the capillaries

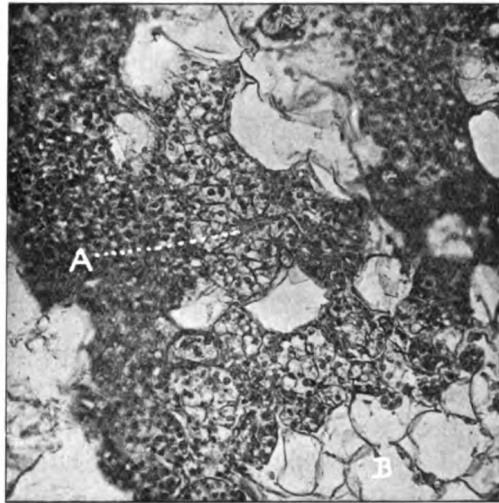


FIG. 13.

Parathyroid gland (Case IV), hæmatoxylin-eosin, showing "watery clear" cells (A).  
There is a large amount of interstitial adipose tissue (B). ( $\times 200$ .)

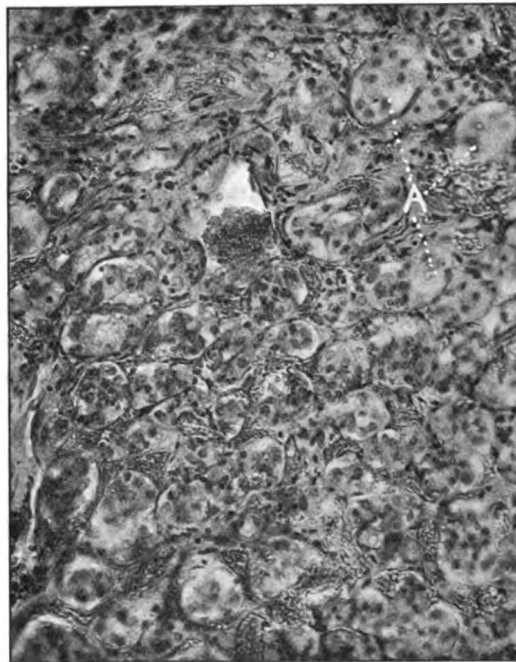


FIG. 14.

Pituitary body (Case IV), hæmatoxylin-eosin, showing the many degenerated  
cells in the hind-part of the pars anterior (A). There is marked hyperæmia.  
( $\times 200$ .)

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are somewhat dilated. The *pars intermedia* is thickened, and large colloid-containing vesicles are seen. In one part of the glandular portion there is a small hæmorrhagic patch. The glandular *pars anterior* contains abundant eosinophile cells, especially near the *pars intermedia*. There are many degenerated cells in the hind-part of the glandular portion. The cyanophile cells are also seen in great number. In some parts the cells are in a state of commencing degeneration. In the glandular portion many follicles contain colloid (*see fig. 14*).

(4) *The Pineal Gland*.—In the hind-part of the gland there are many masses of brain-sand of various size, stained with eosin. The intralobular connective tissue is somewhat thickened.

(5) *The Adrenals*.—The cells of the cortex of both right and left adrenals which take the Scharlach lipid stain are relatively few in number.

(6) *The Ovaries*.—Both right and left ovaries are fibrotic. There are many corpora albicantia and a somewhat large corpus luteum. No lutein cells are seen.

*Résumé*.—The changes in the thyroid gland differ from those previously described from the fact that although there is an atrophy of the glandular structure there is no evidence of a chronic toxic inflammatory process in the interstitial tissue, as no lymphocytic infiltration is observable.

### CONCLUSION.

In the first two cases the changes of the thyroid gland are more advanced than the others. All the changes which occurred in the thyroid glands in the first three cases may have had a toxic origin. These changes of the thyroid gland, in which there were marked mental confusion and depression, correspond entirely with the changes observed by Dr. Mott and Dr. Brun in the third case described by them.<sup>1</sup>

The enlargement of the pituitary body, especially of its glandular portion in conjunction with the changes of the thyroid gland, has been observed by Rozowitch, Schonemann, Ponfick, Boyce and Beadles, Mott and Brun. In the first three cases the pituitary body, especially its glandular portion, is much enlarged. In Case IV the pituitary body is, on the contrary, comparatively small. From this it may probably be inferred that it may become larger, according to the progress of the changes in the thyroid gland.

In the first two cases the microscopic examination of the pituitary body showed a marked activity of function. In Case III the pituitary body was very large, showing, in general, an activity of function, though the *pars anterior* shows commencing atrophy, marked by an increase

<sup>1</sup> *Proceedings*, 1913, vi, p. 89.

of connective tissue. In Case IV it shows in one part a state of commencing degeneration of the cells, but other parts show a marked activity of function.

Although the parathyroid gland is closely attached to the thyroid gland, it did not show an increase of connective tissue or lymphoid cell infiltration met with in the thyroid gland in the first three cases. The fact is of some importance in showing that a toxic condition of the blood only is not responsible for the changes noted in the thyroid gland, and supporting the view that this condition is not a general one, but due to progressive changes in the gland of the nature of a thyroid insufficiency. This thyroid insufficiency was most marked in the first case. In Cases I and II the parathyroid gland suggests an increase of function; on the contrary, in Case III it shows, here and there, a necrotic process of the cells, suggesting that the function, in general, is lessened. In Case IV the right parathyroid gland shows an increased functional activity, while the left shows a lessened function. It is difficult to form any conclusion about the correlation between the thyroid and parathyroid glands from these histological observations.

The pineal glands of all cases show noteworthy changes which could not be definitely correlated with the changes of other glands or mental disorder.

The four cases showed under Scharlach staining a deficiency of lipoid in the cortex of the adrenals; but on reference to the notes of post-mortem examinations it was found that the patients had died of acute infective disease—viz., broncho-pneumonia—which is the most frequent immediate cause of death of the insane. Elliott has shown that the lipoid is diminished in cases of death from infective disease.

In the first three cases of hypothyroidism, the patients during life had suffered with ovarian disease. It may be remarked that these were the cases in which there was not merely a glandular atrophy, but there was also a marked chronic inflammatory interstitial change, and in these three cases Dr. Mott has found the perinuclear chromatolysis of the ganglion cells of the central nervous system, similar to those previously described by him in conjunction with Dr. Brun.

The systematic examination of all the ductless glands in these cases excludes the probability that changes in any other ductless glands than the thyroid can be held accountable for the mental symptoms and the histological changes found in the central nervous system.

It is of interest to note that examination of the blood and cerebro-spinal fluid in these cases of hypothyroidism did not yield a positive

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Wassermann reaction, and therefore syphilis as a cause can probably be excluded.

Since this communication was read I have examined the ductless glands and reproductive organs of a male, No. 43, Table I, in which the thyroid gland weighed 11.5 grm. The thyroid showed a considerable diminution of colloidal vesicles and a fibrotic atrophy, but there was no lymphocytic infiltration as seen in Cases I, II, and III. This case showed no increase in size of the pituitary body. Both testicles exhibited fibrotic atrophy and complete destruction of the glandular structure. The spermatid tubules were entirely replaced by fibrous tissue. The case is of interest in the fact that Dr. Mott finds no evidence of the characteristic universal perinuclear chromatolysis (*vide* p. 59).

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## Studies on Endocrine Organs of Dementia Præcox.

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(Communicated by F. W. MOTT, Major R.A.M.C.(T.), M.D., F.R.S.)

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### (I) INTRODUCTION.

THE fact that dementia præcox commences at puberty or in early adolescence may be associated in some way with perverted function of sexual glands. The histological changes in the brain are generally regarded as insufficient evidence to account for the signs, symptoms and progress of the disease. There is reason, from the results of investigations of endocrine organs, for supposing that these organs are associated functionally with the sexual glands and the metabolism of the nervous system. The endocrine organs, especially the sexual glands, by internal secretion may influence, not only the secondary characters, but the mental character.

Many authors have studied the changes of endocrine organs in

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dementia præcox. Here I give a brief review of recent literature concerning this subject.

In regard to the changes of thyroid in dementia præcox. Amaldi reported a functional insufficiency in two out of four cases. Benigni and Zilocchi found marked sclerosis in one case. Ramadier and Marchand found, in a female case aged 17, marked sclerosis, and the gland weighed 5 grm. In the other four cases they found more or less sclerotic changes, an atrophy of vesicles and great variation in quantity of colloid; while in one case no changes were observed. On the other hand Parhon and others did not find any sclerotic alterations, but marked distention of colloid in the vesicles. According to the results of most authors the weight of the thyroid was often lighter than normal. As stated above, the changes of thyroid in dementia præcox are not alike in all cases—viz., in some cases an alteration of hyperfunction, while in others sclerosis connected with hypofunction.

In regard to the changes of parathyroid, Parhon and Urechie found a large number of cyanophil cells in one case, while in the other the gland was in a state of rest.

According to Laignel-Lavastine the pituitary body presents no alterations. Benigni and Zilocchi reported on the contrary some alteration in one out of two cases.

Laignel-Lavastine observed a hypertrophy of the cortex of adrenals, with a tendency to form adenomatous nodules, and an increase of pigment in the zona reticularis. In a case of Benigni and Zilocchi's the cortex was altered.

Parhon and Ghiorghiani have studied the menstruation of 216 female cases, of which thirty-five were dementia præcox. In twenty-five out of thirty-five cases they found amenorrhœa. They consider that ovarian conditions are frequent in dementia præcox, and that they are connected with mental disorders and not with age.

According to Marie and Dide there was no alteration in the testes in dementia præcox. On the contrary Laignel-Lavastine and Vigouroux have found sclerosis with diminution of interstitial gland in several cases. Parhon, Olregia and Urechie found that in the first case the testicle of one side was sclerotic, the interstitial cells were diminished, and the spermatogenesis was nearly absent; while in the testicle of the other side the interstitial cells were numerous, with abundant lipoid, but the spermatogenesis was scarce. They found in the second case equal alteration of sclerosis, an absence of spermatogenesis, but no changes of interstitial cells.

The above is a brief sketch of the results observed by many authors. These changes are multifarious and may not be the effect of mental disorders, because in most cases of the insane complications are found, and these, especially chronic diseases, may cause several changes in the endocrine organs.

During my study in the Pathological Laboratory, Claybury Asylum, under the guidance of Dr. Mott, F.R.S., to whom I desire to express my cordial thanks for his kindness, I was present at a great many post-mortem examinations of the insane, including five cases of dementia præcox, of which two were male and three female. In the case of a male and two females this condition was combined with chronic tuberculosis; and a male and a female died from broncho-pneumonia after a short illness.

Microscopic examinations of the endocrine organs of these two cases were made, and a description follows.

#### (II) THE METHOD.

The materials were preserved in 10 per cent. formalin, except the adrenals, which were fixed in Müller-formalin. Some preparations from the pineal glands, thyroids and ovaries were embedded in celloidin, the others were embedded in paraffin. The staining methods used are hæmatoxylin-eosin, Van Gieson's stain, Scharlach or Sudan III, hæmatoxylin and Heidenhain's iron-hæmatoxylin.

#### (III) REMARKS ON CASE I.

E. S., aged 24, single; former occupation a beer bottler. Admitted to Claybury Asylum on March 28, 1914. First attacked at the age of 23. Clinical diagnosis, dementia præcox. Died on February 19, 1915.

According to the certificates the patient gesticulates and poses. He states that he ought to be in the secret society, but he also states that he does not know what the secret society is. He states that the attendant is his "daddy" and that he came here to see him. The mother stated that the patient had been talking funnily for a year; six weeks ago he gave up his job to better himself. Later he went back and first sacked the foreman and later all the staff. He said he was a millionaire and would make the mother a titled lady.

*State on Admission.*—Good physique, fair nutrition. Expression is confused; attitude is restless. Respiratory and circulatory organs show nothing special. Teeth carious. Reaction of urine acid; its specific

gravity is 1,035. Slight fine tremor of hands. Pupils are medium size, reaction normal. Plantar flexion normal. Knee-jerks are brisk.

*Mental Condition.*—He often elevates his eyebrows with a restless starting expression. He reacts slowly to questions. There is marked impairment of memory. His conversation is rambling. His method of expressing himself is often slow and there is a tendency to repeat phrases. His remarks are often foolish and incoherent. He is unable to realize his position.

*Progress of Case (March 30, 1914).*—He is weak-minded, and says he wishes to be a doctor. He wishes to join a secret society so that he can better himself. He is anxious to discover a lady of title who will marry him. He is in good health and condition. He does not improve mentally; is dull and apathetic. He was unable to interest himself in anything.

On February 18, 1915, he was put to bed with temperature 101° F. The next day the temperature was 103° F. His pulse was very poor. He failed gradually and died that day.

*Autopsy (made by F. W. Mott, Major R.A.M.C.(T.), M.D., F.R.S.).*

A male, fair physique, nutrition good; post-mortem rigidity in hand and arms; lividity on dependent parts of hands and arms; no bruises nor bedsores; no external mark of syphilis.

The skull *nil*. Dura and pia mater nothing noticeable. Pia-arachnoid strips with difficulty. The convolution is complex. No general nor local softening. The pituitary body is small; weighed 0.57 gm. The pineal gland is larger than normal; weighed 0.17 gm. The thyroid is large and pinkish, and weighed 18.3 gm.

The thorax shows normal appearance. The ribs are brittle; the cartilage is completely ossified. The posterior border and apex of right pleura are adherent; there is no fluid. Left pleura is free; no fluid. Bronchi are congested. Right lung is emphysematous. The apex of lower lobe of left lung is solid with red hepatization. Heart muscle firm. Aortic and mitral valves are competent. Coronary arteries patent. Aorta,  $\frac{3}{4}$  in. in diameter at the ascending portion. Thymus persistent; weighed 6.5 gm.

The liver is congested and fatty. The gall-bladder contains dark bile: no gall-stones. The kidneys are pale; capsules strip readily. The right adrenal is distinctly yellow; weighed 8.8 gm. The left adrenal shows hæmorrhage in medulla; the cortex is less yellow than

normal; weighed 10·7 gm. Intestines and other organs show nothing of note.

The Wassermann reaction of the serum and the spinal fluid is negative.

*Cause of Death.*—Broncho-pneumonia.

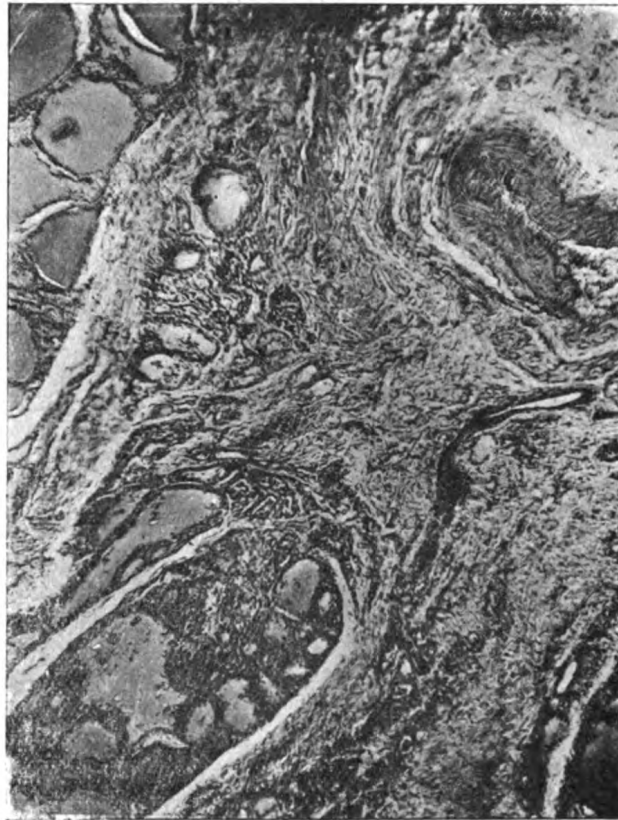


FIG. 1.

The thyroid of Case I, male, showing marked increase of intervesicular connective tissue. The vesicles, which contain colloid, vary very much in size. In some of them a debris of cells is seen. The intima of artery is somewhat thickened. Celloidin. Hæmatoxylin-eosin. ( $\times 60$ .)

*Microscopic Examination.*

(1) *The Thyroid Gland.*—The vesicles vary considerably in size and are filled with colloid, which is stained delicate pink by hæmatoxylin-eosin. There is marked increase of intervesicular connective tissue. The epithelial cells are generally flattened; their cytoplasm contains

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fine eosinophil granules. In some vesicles a débris of cells is mingled with colloid. There is some thickening of intima of arteries (fig. 1).

(2) *The Parathyroid Glands.*—The three external parathyroids look compact under low power, and a great many watery, clear cells, and a few oxyphil cells are seen. The cytoplasm of the clear cells is not stained by eosin, while the nuclei are stained distinctly by hæmatoxylin. Some of the cells are large. There is no follicular arrangement of the cells.

(3) *The Thymus.*—The remainder of the parenchyma is embedded

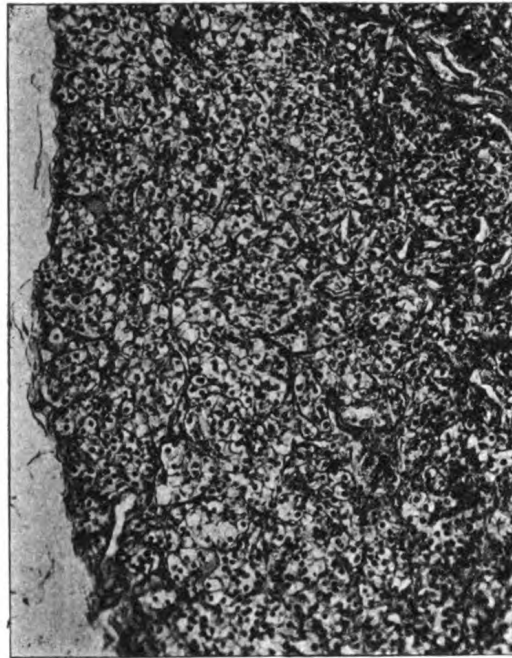


FIG. 2.

The parathyroid of Case I, male, showing watery, clear cells, which occupy nearly the whole section. Paraffin. Hæmatoxylin-eosin. ( $\times 90$ .)

in adipose tissue. The cortex is approximately reduced. A few Hassall's corpuscles, which have undergone hyaline degeneration, are seen, enclosed in the epithelial cells of medulla.

(4) *The Pituitary Body.*—The *pars glandularis* is compact. The eosinophil cells are plentiful in the middle. Towards the periphery their number is reduced and the cyanophil and principal cells are on the contrary increased. The connective fibres are increased throughout.



A few follicles are seen. The *pars intermedia* is somewhat thickened. In the cleft there is a slight amount of hyaline substance, which is stained light red by eosin. Nothing noticeable in the *pars nervosa* (fig. 3).

(5) *The Pineal Gland*.—In the hind part of the gland are seen a small cyst and brain sand, which varies in size and shape. On the whole the section shows complete involution.

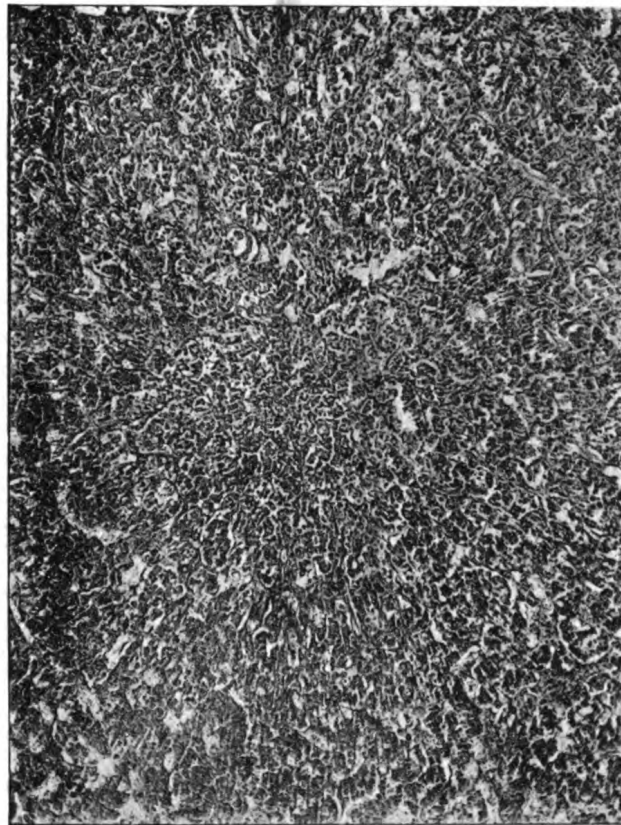


FIG. 3.

The pituitary body of Case I, male, showing an abundance of eosinophil cells. The section looks compact. Paraffin. Hæmatoxylin-eosin. ( $\times 60$ .)

(6) *The Adrenals*.—The cortex is somewhat reduced in thickness. A few cortex cells contain abundant lipoid substance, which is stained red by Scharlach or Sudan III, but in the majority this substance is greatly diminished.

(7) *The Testes*.—The connective tissue between the tubules is thickened. The interstitial cells are numerous and contain much lipoid substance, which is stained by Scharlach. Most of Sertoli's cells do not contain lipoid. There is very slight spermatogenesis.

#### (IV) REMARKS ON CASE II.

N. D., female, aged 33, single; former occupation, a bookfolder. Admitted to Claybury Asylum on December 7, 1904. First attack when aged 23. Clinical diagnosis, dementia præcox. Died on November 10, 1914.

According to the certificates the patient says that to-day is about November 18, and that she does not know the day of the week. When asked if she is still tired of life she replies that she is sorry for her past sins and wishes to be good.

She went off quite suddenly, became strange and depressed, whereas she was previously bright and cheerful. She tried to commit suicide by throwing herself into the dock. She was taken to the St. George's-in-the-East Infirmary by a police constable and subsequently transferred to the Asylum. A sister at the infirmary says that the patient told her that she was tired of life and had been refusing food. She is very depressed and confused in manner.

Before she had the attack *her periods stopped*. She suffered from anæmia and had taken Bland's pills for her menses. After she came to the Asylum she complained of pain and recurrence of periods. She recognized her sister, but her sister and her friends noticed that she was quite irresponsible. Occasionally she would smile. Her expression had gone and her hands were cold.

During the first eighteen months her friends had hoped that she would get better, and she looked forward to it. Her sister came one Sunday and instead of finding her in the corridor she was in the ward and a change was noticed. Since then her mind has become worse.

*Progress of Case (December 12, 1904)*.—She is suffering from melancholia. She is dull and disinclined to answer questions. States she attempted to drown herself but was saved by a policeman. Admits being tired of her life, and that voices speak to her. She does not know where she is: thinks it is Dartford. Says her maternal grandmother was in Dartford Asylum, where she died; also her paternal aunt is in an asylum. She gazes vacantly about her; is in poor health and con-

dition. November 2, 1911: She is the subject of chronic melancholia. She wanders about in an aimless manner, taking no notice of what occurs around her. There are suicidal tendencies. She rarely speaks. Habits faulty. She is in good health and condition. Her mental condition became worse, and she died on November 10, 1914, after a short illness.

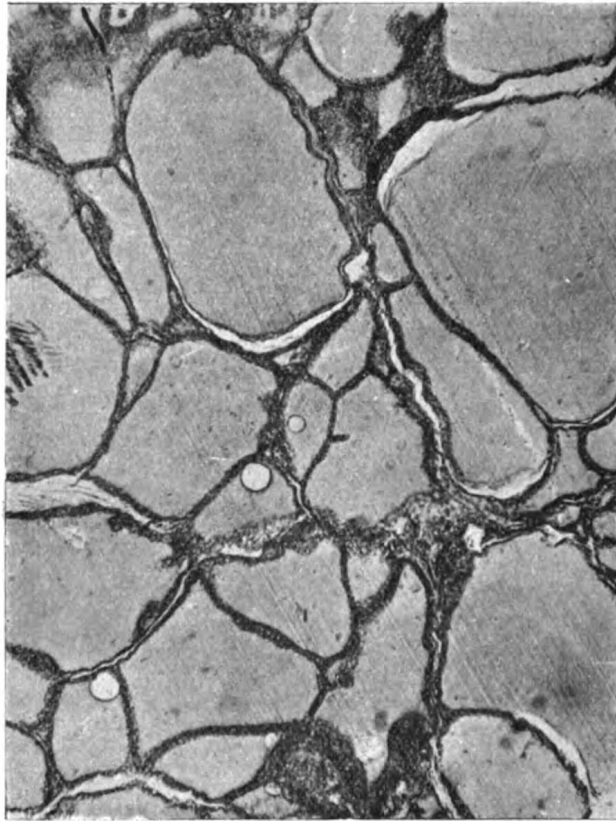


FIG. 4.

The thyroid of Case II, female, showing large vesicles distended with colloid. The epithelial cells are generally flattened. Some vacuoles in the colloid. Celloidin. Hæmatoxylin-eosin. ( $\times 60$ .)

*Autopsy (made by F. W. Mott, Major R.A.M.C.(T.), M.D., F.R.S.).*

A female, well nourished, physique good. Some post-mortem lividity; no external marks of bruises or bedsores; no deformity nor local atrophy; no external marks of syphilis.

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The skull is normal. The dura and pia mater have a normal appearance. The pia-arachnoid is also normal. The subdural and subarachnoid spaces show nothing special. The cerebrum is symmetrical. No special marks of brain. The pituitary body is comparatively small, weighed 0.4 gm. The pineal gland is pink, weighed 0.15 gm.

The right and left pleuræ show no adhesion nor fluid. The bronchi

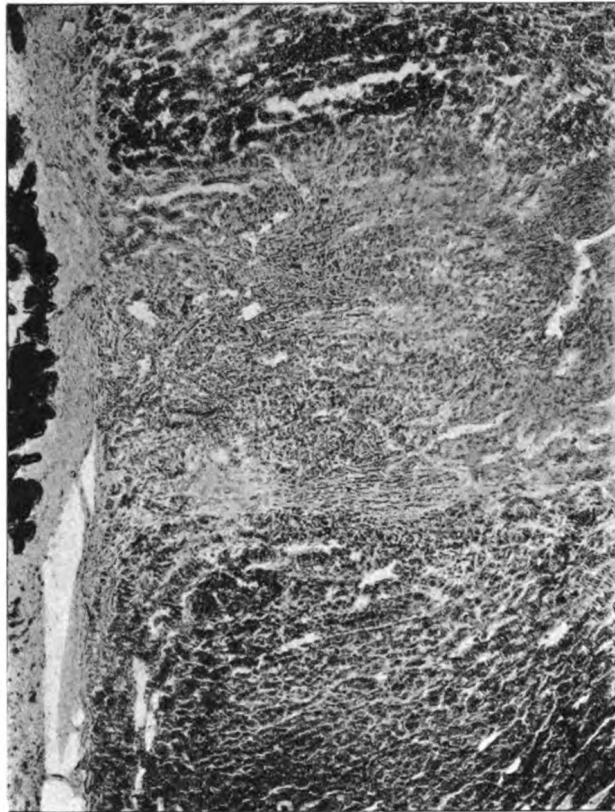


FIG. 5.

The left adrenal of Case II, female, showing a bundle of connective-tissue fibres running through the cortex towards the medulla from the capsule. The lipid substance, which is shown by dark patches, is scarce. On left extremity adipose tissue is seen as dark spots. Frozen section. Scharlach-hæmatoxylin. ( $\times 60$ .)

are congested: the bronchial glands show no swelling. The thyroid is small and pink, weighed 7.7 gm.

The right lung shows patchy broncho-pneumonia, especially of the

upper lobe, and to a less degree of the lower lobe. Most of the lower part of the left lung is solid with congestive œdema of the whole lung. All parts float in water. Both lungs have the appearance of having been quite healthy before the onset of the pneumonia. The heart is small; the valves are normal; the muscle has a rather dark œdematous appearance. The aorta shows hypoplasia; it is only  $\frac{3}{4}$  in. in diameter just above the sinus of Valsalva.

The liver is congested, normal in size. The spleen is also congested.



FIG. 6.

The left ovary of Case II, showing an early involution. A few atretic follicles are seen in the photograph. Celloidin. Hæmatoxylin eosin. ( $\times 60$ .)

There is nothing of note in the kidneys and intestines. The adrenals are small, the right weighed 2·8 gm., while the left weighed 3·4 gm. The uterus is infantile; ovaries small and atrophied, the right weighed 1·8 gm. and the left 2·7 gm.

*Cause of Death.*—Broncho-pneumonia.

*Microscopic Examination.*

(1) *The Thyroid Gland.*—Many of the vesicles are very large, while some of them are small. Generally the vesicles are distended with colloid, which is stained delicate pink by hæmatoxylin-eosin. In the colloid many vacuoles are seen. The epithelial cells are distinctly flattened. Their nuclei are also flat and are stained uniformly dark by hæmatoxylin (fig. 4).

(2) *The Parathyroid Glands.*—The whole section is compact. The eosinophil cells exceed in number the cyanophil cells. There are some follicles, which contain hyaline substance, stained light red by eosin. All the cells have follicular arrangements. The interfollicular connective tissue is somewhat increased.

(3) *The Pituitary Body.*—The *pars glandularis* is generally congested. There are abundant eosinophil cells. The cyanophil and principal cells are far less in number than the former. Follicles, which contain hyaline substance, are seen here and there. A great deal of hyaline substance is seen in the cleft. The *pars intermedia* shows nothing remarkable, but in the *pars nervosa* many droplets of hyaline substance are seen.

(4) *The Pineal Gland.*—The interlobular tissue is markedly thickened. Sand particles, varying in size and shape, are seen here and there.

(5) *The Adrenals.*—There is a striking diminution of lipid substance in the cortex cells. In many parts of the left adrenal the connective fibres are seen running towards the medulla through the cortex, from the capsule. The medullary part seems to be reduced in thickness (fig. 5).

(6) *The Ovaries.*—In the series of sections of the right ovary there are seen a few corpora candicantia and two corpora albicantia. A few atretic follicles are seen. In the middle a small corpus luteum with a few lutein cells are seen. The left ovary contains a few corpora candicantia and a corpus albicans; a few atretic follicles are seen. On the whole it shows the appearance of undergoing an early involution (fig. 6).

## (V) SUMMARY.

The thyroids have an entirely contrary appearance in the male and female—viz., a tendency to hypofunction in the male and to hyperfunction in the female.

The glands are on the whole small, especially in the female. In the male the parathyroids contain watery, clear cells and a few eosinophil cells, and in the female, on the contrary, many eosinophil cells.

The sexual glands and adrenals were very small in the female. The diminution of lipid substance in the cortex cells of adrenals may be due to the acute disease, as stated by Elliott.

Striking changes are seen in the sexual glands — i.e., very slight spermatogenesis in the testes, and an appearance of undergoing an early involution of ovaries.

In Case II the menses were irregular, as noted in the history.

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# THE PATHOLOGY OF VENEREAL DISEASE.<sup>1</sup>

BY

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“THE first duty of the State is to prevent disease, failing that to cure disease, and failing that to prolong life and relieve suffering.” This dictum, I believe, will especially commend itself to a meeting held in The Royal Institute of Public Health, and particularly at the present time is it a suitable preface to a Lecture on the Pathology of Venereal Disease. Huge sums of money have been expended in the past in the building and upkeep of costly, even palatial, infirmaries, lunatic asylums, houses for the blind, the deaf, the paralysed and the feeble minded, and it is certain that a considerable portion of the population of these institutions would never have been in them, had it not been for venereal infection. The State has, up to a few years ago, carried out extravagantly and wastefully its duty at the wrong end ; from the rational and economic point of view, its aim should have been to find out what brought the majority of people into these institutions, suffering with chronic, incapacitating, incurable and fatal diseases, with a view to prevention or cure. Brains not bricks were wanted. The State has at last awakened to the wisdom of the words of the great philosopher Francis Bacon who said : “ To pronounce disease incurable is to establish negligence and carelessness as it were by a law, and to screen ignorance from reproach.” Parliament, mainly owing to Mr. Lloyd George, and only within quite recent years, has come to realize that the prevention and often the cure of many infective diseases, depend largely upon the efficient organization of pathological laboratories. Prior to the outbreak of the War, the House of Commons in the Estimates for 1914-15 voted a grant of £50,000 to assist in the provision for laboratory facilities “ with a view to the prevention,

<sup>1</sup> A Lecture (with lantern demonstrations) delivered at The Royal Institute of Public Health, 37, Russell Square, W.C., on Wednesday, May 9, 1917, at 4 p.m., in connection with the Course of Lectures and Discussions on “ Public Health Problems under War, and After-War Conditions,” Lieut.-Colonel L. W. Harrison, D.S.O., M.B., in the Chair.

diagnosis and treatment of diseases in general." Also the putting into force of the recommendations of the Royal Commission is further proof of a new attitude of Parliament towards pathological research in the prevention, diagnosis, and treatment of diseases. But pathological science, in respect to the effects of venereal diseases in producing affections of the mind and body, has not only had to struggle against negligence, carelessness and ignorance, but against prejudice and a false sentiment that these diseases are a punishment for sin, therefore the State should make no effort to condone sin by State aid of measures for prophylaxis and cure. But to be logical, the State by accepting these premises as an argument against free prophylaxis and cure, should have made no provision whatever for relieving suffering, and prolonging the life of persons suffering with diseases arising from venereal infection. The sin is condoned just the same, but unfortunately from an economic and humane point of view the vast sums of money expended in this way are in a great measure wasted in maintaining the survival of the unfit. The public conscience has however at last been aroused, and sensible men and women in all ranks of society are beginning to regard this question from a saner point of view. The ignorance, prejudice and false sentiments that led to a conspiracy of silence and have condemned countless innocent women and children to untold injury, misery, suffering and death, are being swept away.

#### CAUSES OF NON-RECOGNITION OF VENEREAL ORIGIN OF INCAPACITATING AND KILLING DISEASES.

How has it come about that we have not recognized that a considerable proportion of the incapacitating and killing diseases were directly or indirectly the result of venereal infection? Well, I am inclined to think it is in a measure due to the fact that politicians consulted the Registrar-General's returns, and they found relatively few people died from syphilis or gonorrhœa, and they were satisfied ; but had there been a Minister of Public Health who was acquainted with the pathology of venereal diseases, he would have known how fallacious these statistics are. For it is seldom that venereal disease is fatal in the early stage of the disease, and the medical practitioner, who knows that the friends of his patient will see the death certificate, does not record the fact that the disease was of venereal origin. I may mention that Sir Wm. Osler stated in his evidence before the Royal Com-

mission that venereal disease was in his judgment third or fourth in the order of killing diseases.

Medical science, by its nomenclature, is also partly to blame, for it is content to add "itis" to the Greek or Latin names of the organ or structure affected, as signifying that the disease was an inflammation of that organ or structure; and these terms persist in spite of the fact that pathology teaches that inflammation is not a disease, but a vital reaction of the tissues to injury, whether it be traumatic or due to chemical poisons, such, for example, as are elaborated by pathogenic micro-organisms invading the tissues. Inflammation, therefore, will occur in any organ or tissue of the body, in which the specific organisms of syphilis or gonorrhœa may chance to enter and multiply. In regarding inflammation as the disease, we have blamed Nature's defence against the pathogenic organisms, and the attempt to repair the injury they have caused. Certainly the obvious signs of inflammation, calor, dolor, tumor, rubor, described by the ancients, indicate an afflux of blood, and the protective pain nerves are excited thereby. But what does the microscope show? It shows that an increased flow of blood, to the part is followed by the migration of an army of phagocytes from the small veins and capillaries to battle with the organisms.

#### THE PATHOLOGY OF GONORRHŒA.

In the case of gonorrhœa we have an acute inflammation of the structure invaded by the gonococcus, usually the mucous membrane of the genital organs, causing heat, pain, swelling, and redness, and a purulent discharge. Now the microscope shows that this discharge largely consists of the white blood corpuscles, containing a many-shaped nucleus, called therefore polymorpho-nuclears. We find, moreover, that these leucocytes, which have migrated from the congested blood-vessels and capillaries, have engaged in a death struggle with the invading organisms; for you can see them lying in pairs or groups of four in the substance of the white corpuscles. They have been eaten up, but not digested, and on account of this swallowing property of these particular leucocytes they are termed phagocytes. They behave just the same as amœbæ.

Now the discovery of the specific organism of gonorrhœa by Neisser has been of the greatest importance in diagnosis. He showed that it has a characteristic shape like a bean; it is found

in the leucocytes and occurs in pairs, hence it is termed a *Diplococcus intracellularis*. The organism has specific cultural characteristics and staining reaction; it is Gram-staining negative. There is only one organism that can be mistaken for it and that is the meningococcus, which is the specific organism of cerebro-spinal meningitis. The location however of the two organisms will prevent any mistake being made. The discovery of the specific organism of gonorrhœa has been of enormous value in diagnosis; for it enables the doctor to determine whether a muco-purulent discharge from the genital organs is due to gonorrhœa in the early and curable stage of the disease. Moreover, its discovery by the microscope or not after careful examination enables the doctor to decide whether a man is completely cured, and not likely to infect his wife if he married. Many men honestly believe they have been cured; others may have been told they are cured, yet careful examination of the urine taken after certain precautions have been adopted, may show gonococci, which have been lurking in the prostate gland or vesiculæ seminales. Countless innocent married women have suffered from serious pelvic disease, causing prolonged ill-health and suffering, rendered sterile by affection of the Fallopian tubes, and denied thereby the joy of motherhood, owing to gonorrhœal infection by their husbands, who in a large number of cases believed that they had been cured of the disease, and were therefore non-infective before marriage. Again, purulent ophthalmia of new-born children can be diagnosed as of gonococcal origin, and treated successfully, so that blindness is averted. According to the evidence of Mr. Bishop Harman 55 to 58 per cent. of blindness in 1,100 blind children was due to venereal disease; gonorrhœal ophthalmia was responsible for 24 per cent. The education and examination of midwives before they are permitted to practise, and notification of ophthalmia neonatorum will in the future, it is hoped, abolish this disease as a cause of blindness. Already the results have been most successful. Consider the economic saving to the State and the influence on the birth-rate (a very important matter after the War) which the prevention of the spread of gonorrhœa would have.

The pathology of gonorrhœa teaches us that prophylactic measures should be advocated and adopted to prevent the gonococcus effecting a lodgment in the tissues, and failing that to adopt as early as possible effective curative measures to eradicate

it before it has spread to the deeper structures, and become inaccessible and incurable. Clap, the popular name for gonorrhœa, is not such a trifling disease as many men think. It causes stricture of the urethra, and serious complications may arise therefrom in later life. All the witnesses who gave evidence before the Royal Commission were emphatic on this point. Although as a rule the pathological effects are limited to disease caused by direct local extension along the mucous membranes, and the organism is rarely disseminated in the body; nevertheless, they may be, and cause a very intractable and severe form of joint disease, gonorrhœal rheumatism. This is liable to happen when the deeper structures are invaded. Lastly, the discovery of the specific organism of this disease may be of considerable medico-legal importance, as the history accompanying these photomicrographs prove.

#### THE PATHOLOGY OF SYPHILIS.

I will now consider the more important part of my subject, viz., the Pathology of Syphilis, a subject in which I have been more or less interested for more than twenty years as Pathologist to the L.C.C. Asylums, to which post I was appointed with the view of ascertaining the causes of insanity. As a Neurologist and Physician to Charing Cross Hospital, I had long been impressed with the important relation of syphilis to organic disease of the circulatory and nervous systems, and I was surprised, therefore, when appointed as Pathologist, to find little or no mention in the reports of the Asylums or Lunacy Commissioners of syphilis as a cause of insanity: yet 50 per cent. of the males dying in the asylums, and 15 per cent. of the male admissions every year, were general paralytics, and about a quarter of that number were females. I was led to investigate the relation of syphilis to this disease by the following coincidence. I found a boy, aged 16, dying in Colney Hatch Asylum of general paralysis, who had eight years previously been a patient of mine at Charing Cross Hospital, suffering with well marked congenital syphilis. I found that the clinical signs and symptoms and the chronic inflammatory and degenerative changes in the brain differed in no essential from those to be found in the adult. I was soon able to collect in the London asylums forty of these juvenile cases, and autopsies showing similar conditions with those found in the adult, which was clear proof that alcoholism, sexual excesses, anxiety, excitement, hereditary predisposition, the then usually assigned causes of this disease in the

adult, could not be the essential cause in these juvenile cases. I came to the conclusion, therefore, that syphilis was the cause. I claim no priority, for Fournier from his experience had proclaimed that general paralysis and tabes were due to syphilis, but he termed these diseases parasymphilitic, because he believed them to be a degenerative after-effect of the syphilitic poison upon the central nervous system, a view which was accepted till a few years ago, when the spirochæta was discovered in the brain in this disease. Why was it that the medical profession as a body in this country was loth to admit that general paralysis and locomotor ataxy were of syphilitic origin? The answer is that patients suffering with these diseases as a general rule have had syphilis in such a mild form that they have not been aware of infection, and if they have, they have only manifested slight secondary symptoms, and, as a rule, no tertiary symptoms such as gummata and skin eruption. The only explanation of this modified form of the disease is either that the specific organisms have become modified or the individual has inherited or acquired some resistance to the organism whereby it can only multiply in the central nervous system, where it may remain latent from five to thirty or more years before causing symptoms, although its presence there might be inferred by results obtained by examination of the cerebrospinal fluid, made at the time of the appearance of the secondary eruption. Now, before the discovery of the specific organism of syphilis, Krafft-Ebing had clearly demonstrated that the living virus of syphilis must be in the body of a general paralytic, although the individual so affected gave no history of syphilis and showed no signs of the disease. He inoculated nine general paralytics, with no history and no signs of syphilis on the body, with the virus of a typical hard chancre, and watched these patients for 180 days. Not one took the disease; in the light of modern knowledge we know that the reason why they were immune was because the specific organism was active in the brain and all the tissues of the body were sensitized against re-infection. These observations, added to my own experience, made me come to the conclusion, before the discovery of the spirochæta, that if there were no syphilis then there would be no general paralysis or locomotor ataxy.

#### THE SPECIFIC ORGANISM OF SYPHILIS.

The discovery of the *Spirochæta pallida* by Schaudinn and Hoffmann, and the demonstration of its existence in primary,

secondary and tertiary lesions, soon confirmed by innumerable observers in all countries, was an epoch-making discovery; likewise the successful inoculation of anthropoid apes by Metchnikoff and Roux confirmed by Neisser and others, and extended to many mammals lower in the zoological scale, enabled important prophylactic and curative measures to be tried experimentally before being applied to man. Metchnikoff showed that if calomel cream were applied to the seat of inoculation the infection did not occur. Lastly, Noguchi was able to complete the third postulate of Koch, for he was able to grow the specific organisms outside the body *in vitro*. The spirochæta has definite morphological and biological characters by which it can be recognized by the aid of the microscope with dark-ground illumination. I will project two slides showing the organisms when examined under these conditions (*vide* figs. 3 and 4). The detection of the spirochæta in atypical syphilitic sores is of enormous importance in preventing the spread of the disease and of employing curative measures before the organism has generalized in the body, and this dark-ground method of illumination affords a simple and ready method of diagnosis and should be employed in all doubtful cases of venereal sores. The *Spirochæta pallida* has special staining characters by which it can be recognized. Here is a specimen from a mucous tubercle stained by Leishman's stain (*vide* fig. 6):

The organisms are most easily shown in sections of organs and tissues by the Levaditi silver method, and the tissues of fœtuses and children born dead of syphilitic mothers swarm with the organisms, and in the suprarenal capsules and liver may exist in such numbers as to resemble a pure culture (*vide* fig. 7). Out of 40 macerated dead fœtuses and still-born children sent me from Shore-ditch Infirmary I found spirochætæ in 17. In 12 recently sent by Dr. Briggs from Liverpool, they were only found once by my assistant.

Owing to the researches of the Belgian professor, Bordet, with bacteriolysins and hæmolysins *in vitro* and the application of this hæmolytic test for determining the deviation of the complement, Wassermann, Neisser and Bruck applied Bordet's discovery to test the blood of persons who have suffered with syphilis; subsequently the test was applied by Plaut to the cerebrospinal fluid. The blood test has been a valuable adjunct to clinical medicine; but the blood of many people in apparently perfect health, and with healthy

children, who have suffered in the past with syphilis, may give this reaction; it means that the spirochæta is still in the body producing toxins—it does not necessarily mean that it is damaging any vital tissue or organ. The great value of this blood test is that when a patient is suffering with a chronic inflammatory disease of some organ or tissue, a positive reaction of the blood is an indication that the disease may be of syphilitic origin and will yield to anti-syphilitic remedies. Again, if a married woman has had miscarriages and dead children a positive reaction of the blood points to the cause and indicates the treatment required. When the cerebro-spinal fluid gives a positive reaction, it means that the spirochæta is in the central nervous system, and once there it is doubtful whether it will ever be completely eradicated; moreover when the organism has entered the nervous tissue of the brain and spinal cord antisiphilitic drugs such as mercury and the arseno-benzol preparations are powerless; for it is very doubtful if they ever effectually reach and destroy the organisms, whatever be the mode of administration. I am not, however, speaking of syphilitic inflammation of the membranes or of the vessels of the brain and spinal cord, which undoubtedly respond to treatment in a marvellous way, although according to my experience it is in the majority of cases arrest rather than cure that occurs, for relapses generally take place.

The next great advance that was made in the pathology of syphilis, was the discovery by Ehrlich and Hata of a chemotropic substance for spirochæta and yet not organotropic, that is to say a substance whereby the spirochæta of syphilis could be killed without injuring the tissues. By chemotropic I mean a substance that has a chemical affinity for the osmotic membrane covering the organism, but not organotropic or affinity for the osmotic membrane covering the living cells of the body. Salvarsan (606) and its arseno-benzol substitutes, have this affinity for the spirochæta and hence its spirochæticidal properties.

#### PARENCHYMATOUS SYPHILIS OF THE NERVOUS SYSTEM REPLACES PARASYPHILIS.

Lastly, a very important discovery was made by chance and persistence. Noguchi after examining a large number of sections prepared by Moore, of brains of general paralytics stained by the silver method, came upon one badly stained as regards the network



of nerve fibrils and in it he found the spiral organisms. This led him to search again through all the sections prepared from seventy cases. He then found them in twelve. This observation myself and many others have confirmed, and now I have been able, in 100 successive cases, to demonstrate microscopically by dark-ground illumination the spirochætæ in an emulsion of brain tissue in sixty-six (*vide* fig. 7). It is an interesting fact that examination of the contents of the vesiculæ seminales and smears of the testes by dark-ground illumination in forty of these cases of general paralysis did not once show spirochætæ. Moreover the spirochæta has been obtained by Förster in a number of cases in the living active state by removal of a small portion of brain from paralytics during life. Now no one doubts the dictum, "No syphilis, no general paralysis." The prevalence of this disease in a community, as I have shown, may afford an index of the relative incidence of syphilis in the various districts of London. For we can now by the examination of the cerebrospinal fluid diagnose the disease correctly in 97 per cent. of the cases admitted to the asylums. Therefore, the admissions of males and females suffering with this disease from the various boroughs of the County of London, afford an index of the relative incidence of syphilis in those boroughs ten years ago. I say ten years because the average time after infection for the appearance of general paralysis is ten years. It is well known that general paralysis affects the male sex in all ranks, from the highest to the lowest, pretty equally, in our large cities, but in the female sex it is far more prevalent in the lower classes and diminishes as we rise in the social scale. A very eminent physician asked me not long ago whether women suffered with general paralysis? He was surprised when I told him that the proportion of males to females was only about 4 to 1 in the asylums. Naturally they did not come his way, for they are recruited mainly from the ignorant poorer classes of married women and prostitutes. It was interesting therefore to find that West End parishes north of the Thames furnished a larger proportion of male paralytics than East End parishes, but a smaller proportion of female paralytics.

Since pathological investigation has proved that syphilis is the essential factor, should soldiers who have served abroad and been exposed to the terrible stress of this War, when boarded out on account of this disease, have a gratuity or pension awarded, and

should their wives receive no allowance? The disease was not evident when they joined and in the great majority of cases it was not discoverable. The question naturally to be answered is, was it excited or aggravated by the conditions to which the soldier was exposed? In other words, would he have suffered with the disease if he had not been exposed to the terrible mental and bodily conditions of War? According to my observations and experience, severe and prolonged mental stress and excitement causing cerebral congestion may not only aggravate the disease when it has been arrested and is quiescent, but may excite the onset of symptoms. A blow on the head will sometimes result in a syphilitic gummatous tumour of the brain at the seat of the injury.

CONSIDERATION OF THE NATURE OF THE PRIMARY SORE IS OF  
GREAT IMPORTANCE.

A local inflammation is the first obvious result of the growth of the spirochæte at the site of infection, but seldom is it attended by pain or discomfort. The absence of pain or even discomfort in this stage of the disease is a very important cause of its spread. The adoption of Metchnikoff's prophylactic method would undoubtedly greatly diminish the possibilities of contagion in the primary stage when there may be ignorance of infection, the dispelling of which (from the Public Health point of view) is of vital importance. Levaditi has shown that the syphilitic organisms can be found in the tissues at the seat of inoculation, before histological changes can be recognized by the naked eye; therefore before there is any obvious visible evidence the disease may be communicable. The first visible sign may be a papule or pimple, the surface of which may be eroded, superadded infection by other organisms may take place, leading to the formation of an ulcer. The chancre does not by any means always take the typical indurated Hunterian form. There are atypic forms of syphilitic sore, with little or no induration at the base, which result from mixed infection. These were formerly too often regarded as soft chancres, and were either not treated at all, or not until secondary symptoms had occurred. It was the practice formerly to wait until the secondary rash occurred before treatment of these cases was commenced. But we now know that this is too late, the spirochæte will have become disseminated throughout the body. Many cases of general paralysis and tabes give a history of a slight sore, a soft

sore or painless pimple, which was not considered to be syphilitic, but the subsequent history tells another story. Mercurial treatment was commenced when definite secondary symptoms had occurred, and in quite a number of these cases the treatment was continued for years. Nevertheless the patient many years later was affected with these diseases of the nervous system. In consequence, some physicians even asserted that prolonged treatment by mercury was the cause of these grave affections.

#### SYPHILIS OF THE NERVOUS SYSTEM.

In the light of modern pathology we know that the reason why the mercury had no effect in preventing the patient suffering with diseases of the nervous system, in spite of this prolonged treatment, was that the secondary stage marks the dissemination of the specific organism, by way of the lymph and blood streams in all the organs and tissues of the body, including the nervous system. Here it may colonize and set up a gummatous meningitis, affecting the brain and spinal cord, as in the case of sleeping sickness; for when once the trypanosome organism has entered the spinal fluid, it is doubtful whether it can ever be eradicated. Associated with the meningitis is an affection of the arteries, causing a thickening of the inner coat and partial or complete obliteration of the lumen, followed by the occurrence of secondary thrombosis, which causes paralysis of various kinds, loss of speech, of special senses and dementia. Examination of the cerebrospinal fluid would show that the spirochæte was actively multiplying, for the fluid would give a positive Wassermann reaction and a lymphocytosis. I find the teaching of Fournier, who pointed out twenty-five years ago that this form of cerebrospinal syphilis occurs most frequently in the first year after infection and diminishes with each succeeding year, is not yet widely enough known. Only the other day, I saw a case of syphilitic meningo-myelitis with paraplegia missed, because the infection had only occurred four months previously. The practitioner thought it could only occur in the late tertiary stage. There are numbers of persons suffering with incapacitating paralytic and demented conditions arising from this form of cerebrospinal syphilis, which if diagnosed early by modern methods could be cured or at any rate the disease arrested, before the nervous tissue had been destroyed by blocking of the arteries. But the spirochæte may remain latent in the nervous tissue and at

some later period, perhaps five, ten or fifteen years after infection, owing to some coefficient devitalizing condition, it may start growing, and by the toxins it produces a chronic inflammatory change is set up in the brain and spinal cord, with destruction of the nervous elements and the neuroglia and connective tissue proliferation. Such a change occurring in the brain causes general paralysis; in the spinal cord locomotor ataxy; in the optic nerves and tracts an optic atrophy with blindness. But these conditions are often combined; in fact 10 per cent. of the cases of locomotor ataxy terminate in general paralysis, and quite a number of cases of optic atrophy are associated with general paralysis or ataxy. Of 4,134 officers in the Austrian army treated in hospital for syphilis, rather more than 10 per cent. subsequently suffered with one or other of these diseases of the nervous system.

I have spoken first of the most grave, and, therefore, the most important pathological result of syphilitic infection, viz., syphilis of the central nervous system, and I will show a few lantern slides to illustrate the same.

#### SKIN AND BONE LESIONS LESS FREQUENT.

Several witnesses who gave evidence at the Royal Commission remarked that skin and bone lesions are not so severe as formerly, and this, no doubt, is due to the fact that secondary infection by pyogenic and septic organisms, causing destructive suppurative processes with ulcerative necrosis, has been greatly diminished by cleanliness and antiseptics. These serious bone and skin diseases may be less prevalent, but other graver diseases, such as I have been referring to as affecting the nervous system, are not less prevalent. In fact, it is rather a remarkable thing that skin eruptions are seldom seen in general paralysis and tabes. And there are other facts which seem to show that the spirochæte which produces the late quaternary forms of syphilis (general paralysis and locomotor ataxy) is modified in some way. The spiral organism resembles morphologically the spirochæte found in the chancre, but Förster and Tomaszewski failed to inoculate monkeys with the living organisms obtained from the brain of general paralytics during life. May it not be that an organism that produces mild primary and secondary symptoms, and no tertiary symptoms, has been modified and attenuated in its virulence by the widespread use of mercury, and that it (the spirochæte) has acquired a biological defensive action, by making

for the central nervous system instead of the skin, when generalization takes place. If it can enter the substance of the nervous system it is protected from all metallic spirochætal poisons, such as mercury, arsenic and antimony. There are numbers of clinical cases which seem to support this argument; the most conclusive is that of Brosius, who relates that seven glass-blowers suffered with chancre of the lip, and out of five, who ten years later came under observation, four suffered with either tabes or general paralysis.

#### SYPHILITIC DISEASE OF THE ARTERIES.

Nature, even without the aid of therapeutic agencies, tries to combat more or less successfully, according to circumstances, the multiplication of the syphilitic organisms in the body by exciting the blood and tissues to produce antibodies, to neutralize the effects of the toxins and destroy the spirochætes. At the same time the connective tissue cells which surround the inflamed area, and possess a greater resistance to the action of the toxins than the more specialized cell elements of the tissues are able to multiply and condense in such a way as to form a non-vascular, or only slightly vascular, fibrous tissue barrier.

The wall of fibrous tissue which shuts off the infective organism is in many instances a curative process, but in the arteries the replacement of inflammatory tissue by fibrous tissue, although a defensive action, nevertheless leads in the larger arteries to patches of fibrous tissue, and in the smaller (especially of the brain) to a general fibrotic thickening, which results in the loss of elasticity of the vessels. Consequently, arterio-sclerosis is a frequent result of syphilis. When this stiffening and thickening affects the coronary arteries, as this lantern slide shows, it produces malnutrition of the heart and fatty degeneration. It also is a frequent cause of angina pectoris. The syphilitic inflammation may attack the aortic valve and render it incompetent by thickening and stiffening the cusps, so that it causes aortic regurgitation. Syphilitic aortitis is responsible for ninety per cent. of the cases of aneurism of the aorta. It is a common saying that "a man is as old as his arteries," and since syphilis is the most frequent cause of arterial disease occurring between the ages of 25 and 50, it follows that syphilis must tend to shorten life in many ways, unless it is treated in the early primary stage, before the organism has generalized in the body. When generalization has taken place, constitutional symptoms arise from

the multiplication of the spirochætes, the toxins produced escape into the blood and produce anæmia, debility, falling out of the hair, sometimes accompanied by slight pyrexia. Once dissemination by the blood and lymph-streams has taken place, there is always the possibility of latent organisms becoming active and liberating fresh broods into the lymph and blood-stream, although as time passes the blood and tissues acquire greater power of producing spirochæticidal substances. Since every tissue and organ of the body contain lymphatics, and most of them blood-vessels, spirochætes may be disseminated by these circulating fluids in every organ and tissue of the body. The seeds of disease thus sown may not propagate for years, then a favourable moment may occur by a lowering of the natural defences of the tissues by injury, malnutrition, the action of poisons (such as alcohol in excess) and exhaustion. It is therefore obvious that any organ or tissue of the body may become the seat of a diffuse or localized chronic inflammatory process, ending in fibrosis.

#### CONGENITAL SYPHILIS.

The changes in the body in congenital syphilis are exactly the same as in the acquired form. The term hereditary syphilis is not strictly correct. There is no proof of spermatic infection. I think we may regard as certain that every syphilitic child has a syphilitic mother. The study of the family histories of a number of cases of juvenile general paralysis is of considerable interest, for it tends to show that the spirochæte is modified in its virulence by the defensive reaction of the tissues of the mother, for, after a history of miscarriages, stillbirths, children born dead, children dying in early infancy, we find children surviving, who at puberty may occasionally develop general paralysis. This is the first critical period of life. Often one finds a child has done well at school, and even reached the sixth or seventh standard, when the mind begins to show signs of decay, and gradually all the signs of the disease appear. I will show some of these pedigrees of juvenile general paralysis to illustrate some points in connection with congenital syphilis (*vide* fig. 8).

In a letter in the *Daily Telegraph* it was asserted that the children of a syphilitic mother were not syphilitic at birth, but became syphilized after birth by the milk. I contradicted this statement; however I think it is necessary to explain why children born alive of syphilitic mothers do not always give a positive

## CONGENITAL SYPHILIS.

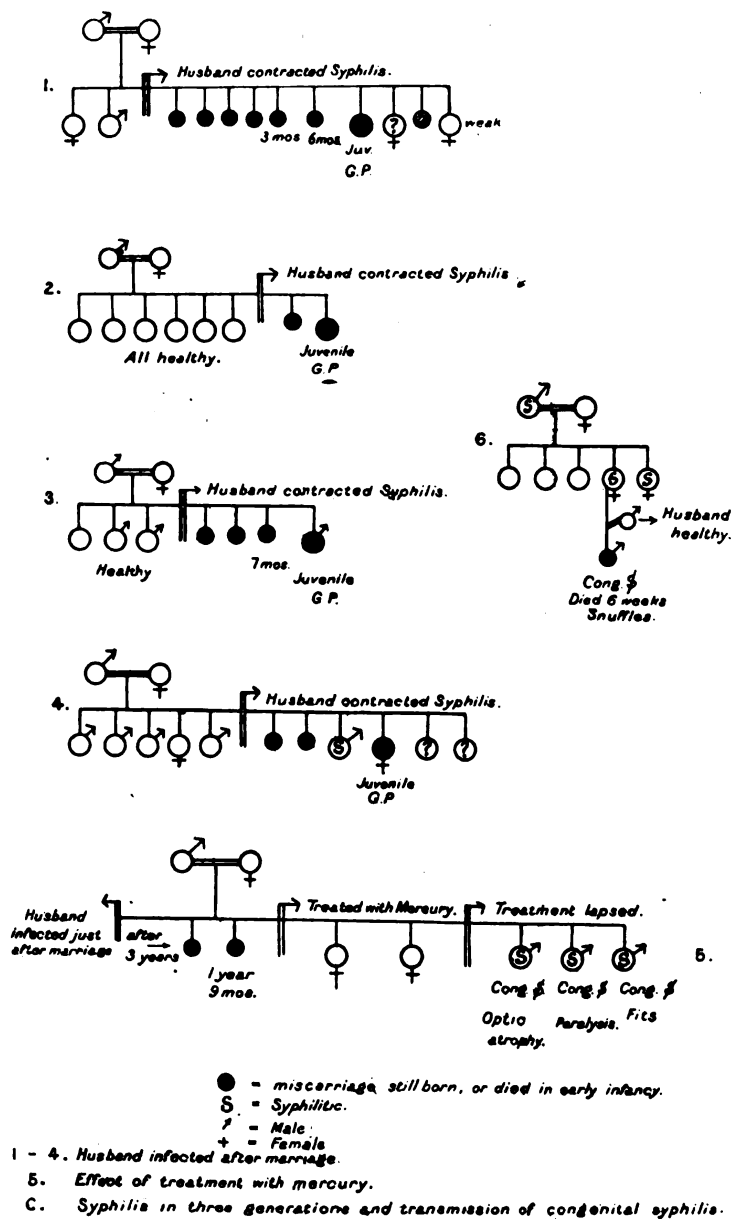


FIG. 8.—Pedigrees of congenital syphilis.

reaction of the blood at birth, and perhaps not till four to eight weeks after birth. But the negative reaction of the blood at birth and for some weeks after does not show that the infection did not take place while the child was developing in the mother's womb or during birth; the child might be born looking healthy, and it would not show signs of disease until the spirochæte had generalized by the blood and lymph streams in all the organs and tissues of the body. The blood reaction is not shown until about six weeks after infection, that is, when the spirochætes have multiplied sufficiently in the body to have produced enough toxins to excite a general reaction of the blood and tissues. It comes just before the secondary rash appears; consequently the child might be infected during the last month of pregnancy or during its passage through the maternal genital structures at its birth. Congenital syphilis is certainly not nearly so common as it was. Nearly all physicians to children's hospitals will tell you that they comparatively seldom see children suffering with congenital syphilis. The blood reaction however shows that a number of apparently healthy children are born of syphilitic mothers, and are syphilitic. Is it that racial immunity is taking place owing to the wider spread of the disease? The racial immunity from prevalence in the past may exist in the population of our large cities, but that is not the case in rural districts where the population has been free from venereal disease.

Now that conscription in Great Britain has taken place, probably the same will happen as in Germany after conscription, when venereal infection spread to the rural districts.

At no time in the history of the British race has the question of the influence of venereal infection upon reproduction been of greater national importance than the present, when the whole virile portion of the population is engaged directly or indirectly in a great struggle for existence, a struggle in which a large portion of the best of our manhood are being destroyed in battle.

Pathology has done its work; it has taught the people the cause, and how it can be remedied, by showing that venereal diseases are due to infection by specific organisms, which, after entering the body, at first multiply locally, setting up in each case a characteristic tissue reaction, and that they then spread to other tissues and organs, and give rise to constitutional disease, which is very difficult to cure. The obvious course is to prevent the





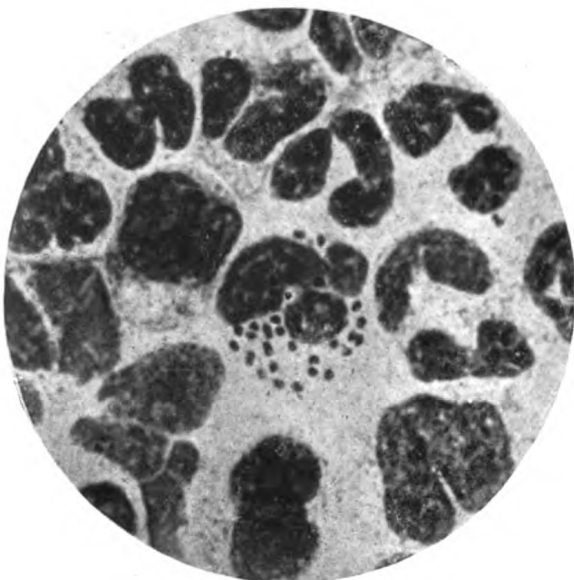


FIG. 1.

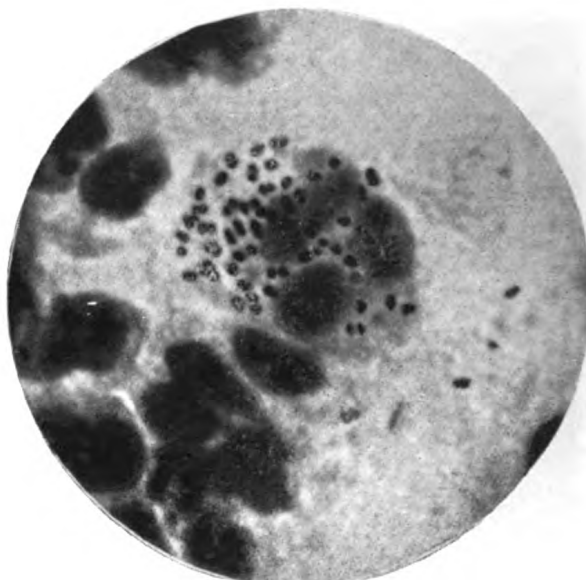


FIG. 2.

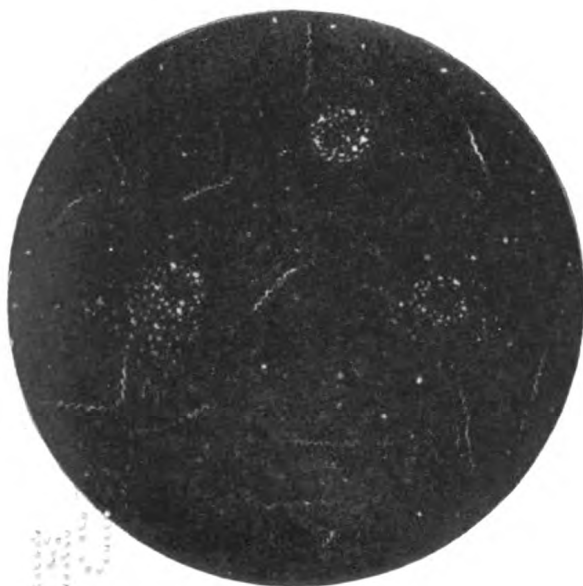


FIG. 3.



FIG. 4.

To illustrate "The Pathology of Venereal Disease," by F. W. MOTT, M.D., LL.D., F.R.S.,  
Major, R.A.M.C. (T.).

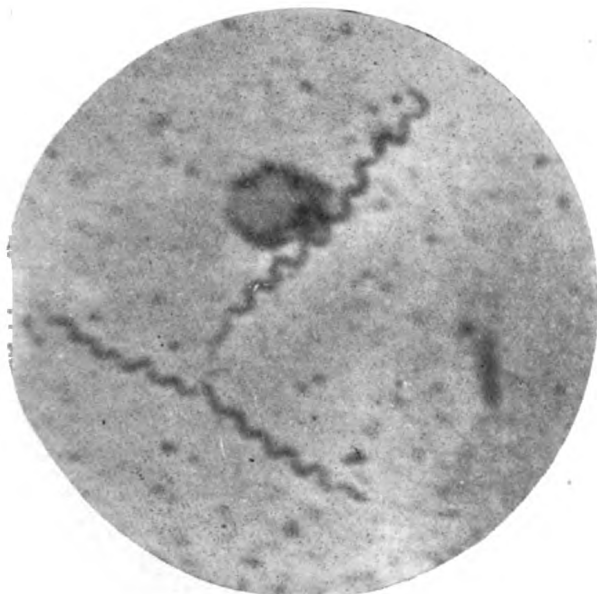


FIG. 5.

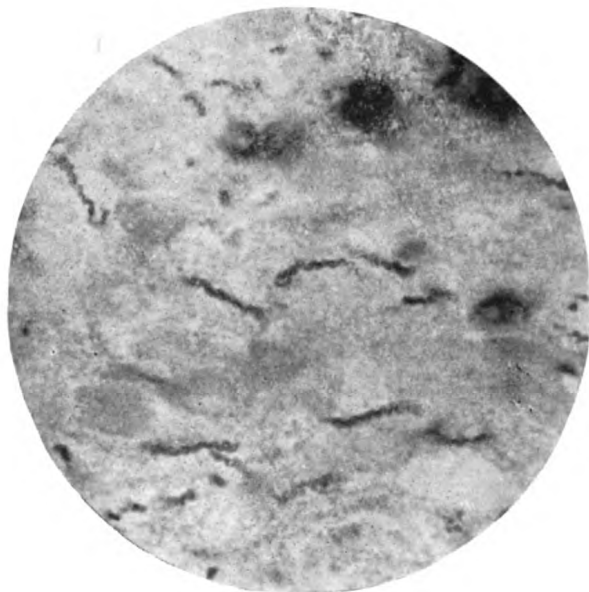


FIG. 6.

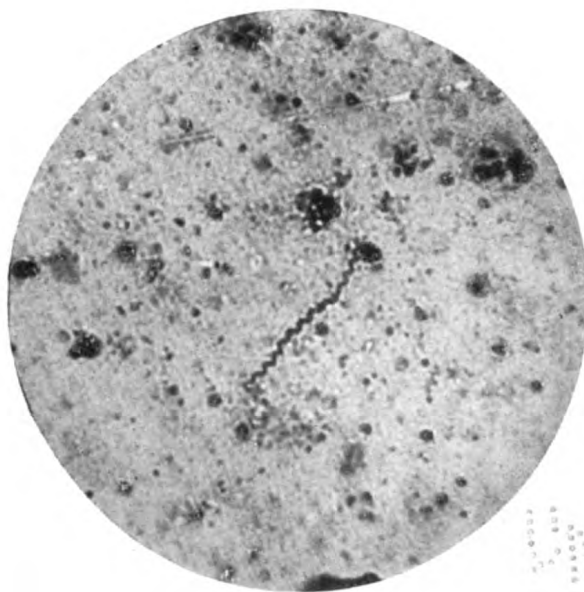


FIG. 7.

To illustrate "The Pathology of Venereal Disease," by F. W. MOTT, M.D., LL.D., F.R.S.,  
Major, R.A.M.C. (T.).



organisms from entering the body by adopting suitable prophylactic measures; failing this, to diagnose the existence of the specific organism while it is still producing only a local reaction, and then to adopt modern curative treatment, with a view of destroying the organisms before they can generalize and colonize in the organs and tissues of the body.

"Fiat lux" is the remedy for the Hidden Plague.

#### DESCRIPTION OF ILLUSTRATIONS.

FIG. 1.—Photomicrograph. Pus from a case of ophthalmia neonatorum. The mother was infected by the husband not long before the birth of the child. Observe the polynuclear leucocytes containing the gonococci. ( $\times 1,500$ ). After Commandon.

FIG. 2.—Photomicrograph. Purulent discharge from the vulva of a little girl showing gonococci in the pus cells. The nurse, the mother, and another little girl were shown to be similarly infected. Observe the kidney-bean shape of the organisms and its occurrence in pairs, ( $\times 1,800$ ). After Commandon.

FIG. 3.—Exudation from a chancre examined by dark-ground illumination. Numbers of spirochætes of syphilis can be seen; they are easily distinguished by their delicate spiral form and spiral movement from the coarser *Spirochæte refringens* which has an undulating movement. ( $\times 1,200$ .)

FIG. 4.—Exudation from a mucous plaque but showing many more of the refringens variety of spirochætes. ( $\times 1,200$ .)

FIG. 5.—Photomicrograph of spirochæte seen in exudation of a condyloma stained by Leishman method. ( $\times 3,000$ .)

FIG. 6.—Photomicrograph of spirochætes in the liver of a syphilitic fœtus, stained by the Levaditi silver method. ( $\times 1,400$ .)

FIG. 7.—Photomicrograph of spirochæte seen in a smear of brain from a case of general paralysis, stained by the Fontana silver method. ( $\times 1,400$ .)

FIG. 8.—Pedigrees of congenital syphilis.



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## Section of Psychiatry.

President — Dr. R. PERCY SMITH.

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### Morphological Investigations upon the Convolutional Pattern of Relative Brains in Man.<sup>1</sup>

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#### INTRODUCTION.

“Wonder en is geen wonder.”  
—SIMON STEVIN.<sup>2</sup>

THE problem of the inheritance of the convolutional pattern in man is far from being solved, and the time has certainly not yet arrived for testing the laws of Mendelian heredity on the basis material now to hand; nevertheless, large fields of statistical and biometric research still lie open for exploration in the near future. We must agree with the conclusion of Professor Sir W. Turner,<sup>3</sup> contained in his statement that “In each order the developmental process which determines the pattern of the cerebral cortex would seem to be regulated by the functional and physical necessities of the animals constituting the order, as well as by the conditions of hereditary descent.” And we may expect the original pattern, proper to each order, to present a certain amount of variations, in accordance with racial, sexual and family peculiarities, although this

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<sup>2</sup> Simon Stevin, born at Bruges, 1548, popularized the decimal system in the Seventeen Netherlands.

<sup>3</sup> W. Turner, “The Convolution of the Brain,” *Journ. of Anat. and Phys.*, 1890, xxv, p. 152.

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has not been thoroughly proved to hold good for the convolutional pattern of the human brain. Moreover, "every furrow—even the sulcus centralis—" as Retzius<sup>1</sup> pointed out, "may be divided into two or more portions, and every furrow may also be connected with the neighbouring furrows." As an infolding of the brain wall at a certain point may be due to the pressure exerted on another point at some distance, "it is not necessarily the change in its direct surroundings which makes a sulcus change, nor necessarily a constancy in its direct contiguities which makes it constant," writes Ariëns Kappers.<sup>2</sup>

These, and other indications, emphasize the complexity of the problem. Numerous factors influencing the points of similarity and dissimilarity in relative brains, will be considered and discussed, so that an attempt will be made to discover the best method of comparison.

Major F. W. Mott, F.R.S., has kindly placed at my disposal for this investigation, material which he has been collecting for more than ten years. He had already submitted to me for investigation the brains of identical twins, which formed the subject of a monograph, published in the *Philosophical Transactions of the Royal Society*. Some ten years ago, Major Mott<sup>3</sup> commenced the study of heredity in relation to insanity, by establishing a card system in the London County Asylums, his objects being threefold—viz., (1) to ascertain if there existed an hereditary resemblance in the convolutional pattern; (2) to ascertain whether certain types of insanity are more prone to be inherited than others, and, if so, whether they are repeated in successive generations; (3) to ascertain if in a family with an insane heredity there is a tendency for the onset of mental disease to occur at an earlier age in the offspring than in the parent (anticipation).

These questions have been dealt with in numerous papers published in the *Archives of the Laboratory*. The number of cards now collected amounts to over 5,000 and 200 brains have been collected. Among them are seventeen pairs of brains of near relatives. Two of these pairs of brains have been carefully described by Dr. Edgar Schuster<sup>4</sup> in the *Archives of Neurology and Psychiatry*, vol. vi, and

<sup>1</sup> G. Retzius, "Das Menschenhirn," Stockholm, 1896, p. 95.

<sup>2</sup> C. U. Ariëns Kappers, "Cerebral Localization and the Significance of Sulci," *Congress of Medicine*, Lond., 1913, p. 371.

<sup>3</sup> F. W. Mott, "The Neuropathic Inheritance," *Proc. Roy. Soc. Med.*, Lond., 1913, vi (Sect. of Psych.), p. 23.

<sup>4</sup> E. Schuster, "Hereditary Resemblance in the Fissures of the Cerebral Hemispheres," *Arch. of Neur. and Psych.*, 1914, vi.



now the Director, Major Mott, has very kindly placed at my disposal fifteen pairs of brains of relatives. This valuable material, which has taken him so long to collect, forms the basis of the investigations which I have carried out in the Laboratory of the London County Asylums, Maudsley Hospital, Denmark Hill. I desire to offer my grateful acknowledgement to the Asylums Committee of the L.C.C. for permission to work there, and especially to the Medical Research Committee for the liberal grant accorded to me, by which I have been enabled to carry on this research in these times of struggle and distress.

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(I) THE MATERIAL USED IN THIS STUDY.

Details as to the material used in this study are to be found in Table A.

The average age of the parents at the beginning of their mental illness is 59·3, that of the children 27·3. The children all anticipate the age of onset in the parents—viz., 43, 8, 25, 21, 17, 44, 50, 31, 49 years. The average difference between the age of the parents and that of the children at onset of the mental disorder is 32 years.

The average weight of the brain of the male parents is 1,136·6 grm.; that of the female parents, 1,032·6 grm.; that of the male children, 1,313·9; that of the female children, 1,181. These small weights are a result of the method of hardening. Brains which have been for a long time in formalin solution, under slow evaporation and the repeated addition of new solutions, lose a fair amount of their weight. Special attention has been paid to this influence. Only one child has a smaller brain than that of the father, it is the daughter B of the second pair. The difference is not great and the brain of the daughter has been four years longer in the hardening solution than the brain of

TABLE A.—DETAILS AS TO THE ORIGINS OF THE SIXTEEN PAIRS OF RELATIVE BRAINS.

No.	Relationship	Difference of age	Age at onset	Age at death	Diagnosis	Infectious complication	Weight of the brain before and after hardening (grammes)	Cause of death
I	A Father ...	43	68	69	Senile dementia	—	Before	Pneumonia
II	B Son ...	...	25	27	Epileptic dementia	Tuberculosis	After	Phthisis (pulmonary)
III	A Father ...	43	46	85	Paranoia	—	1,220	Senile decay
IV	B Daughter ...	...	38	38	Dementia paranoia	Dysentery	1,285	Exhaustion
V	A Father ...	37	53	68	Senile dementia	—	1,160	Arteriosclerosis
VI	B Daughter ...	...	28	34	Imbecility	Dysentery	1,090	Dysentery
VII	A Mother ...	29	61	73	Senile dementia	Rheumatism	1,030	Endocarditis
VIII	B Daughter ...	...	40	41	General paralysis	Syphilis (?)	1,100	Exhaustion, general paralysis
IX	A Mother ...	28	35	47	Chronic mania	Tuberculosis	1,125	Tuberculosis
X	B Daughter ...	...	18	18	Adolescent insanity	Dysentery	1,205	Acute colitis
XI	A Mother ...	31	67	67	Senile dementia	Dysentery	1,210	Senile decay
XII	B Daughter ...	...	23	38	Dementia præcox	—	906	Mitral disease
XIII	A Mother ...	32	66	77	Chronic mania	—	1,140	Senile decay
XIV	B Daughter ...	...	16	50	Adolescent insanity	Rheumatism	935	Broncho-pneumonia
XV	A Mother ...	40	63	75	Chronic mania	Syphilis (?)	1,421	Cancer
XVI	B Son ...	...	32	32	Melancholia	Tuberculosis	1,070	Phthisis (pulmonary)
XVII	A Mother ...	41	75	75	Senile mania	Syphilis	1,370	Senile decay
XVIII	B Son ...	...	26	36	Recurrent mania	Syphilis	1,285	Pneumonia
XIX	A Brother ...	8	26	49	Primary dementia	—	1,480	Pneumonia
XX	B Brother ...	...	34	40	General paralysis	Syphilis	1,480	General paralysis
XXI	A Brother ...	3	29	32	General paralysis	Syphilis (?)	1,170	General paralysis
XXII	B Brother ...	...	28	29	General paralysis	Rheumatism	1,280	General paralysis
XXIII	A Sister ...	6	71	88	Senile melancholia	Rheumatism	1,350	Senile decay
XXIV	B Sister ...	...	67	83	Senile melancholia	—	1,125	Senile decay
XXV	A Sister ...	5	52	61	Delusional insanity	Tuberculosis	1,065	Pulmonary and int. tuberculosis
XXVI	B Sister ...	...	20	58	Delusional insanity	—	1,250	Pneumonia
XXVII	A Brother ...	5	29	30	Melancholia	Tuberculosis	1,305	Pulmonary and int. tuberculosis
XXVIII	B Sister ...	...	25	25	Mania	Dysentery	1,060	Dysentery
XXIX	A Sister ...	3	49	57	Alcoholic dementia	—	1,105	Pneumonia
XXX	B Brother ...	...	40	60	Alcoholic epileptic dementia	—	1,545	Pneumonia
XXXI	A Brother ...	0	...	...	—	—	—	Stillborn
XXXII	B Brother ...	...	...	...	—	—	—	Stillborn

the father, which suggests a loss of weight of greater importance so far as the daughter's brain is concerned.

Degeneration brings about variability ; we may expect degenerated children to have larger or smaller brains than their parents, but the smaller idiotic brains, as a rule, do not reach the asylums, where the material has been obtained. It is also possible that the parents, having a brain weight below the mean weight of the general population, contribute children with a higher brain weight, progressing towards the mean weight of the general population. Although the figures of the brain weights are not very accurate, owing to the differences of hardening, it is interesting to observe that the average comparisons are in accordance with the results of more extensive statistics. But compared with fresh brains, obtained in the same asylum population, there is an average loss of 100 grm. for each group.

In five cases alcoholism of the father seems to have been the origin of the neuropathic heredity ; in only two cases syphilis of the parents is signalized, but in eight cases (out of thirty-two) and three of which are "query" cases, syphilis has been considered as being present. In six out of fifteen cases, there was a marked neuropathic heredity in the family. In twenty cases, out of thirty, an infectious disease existed during the mental condition (the final pneumonia has not been accounted for) ; five times tuberculosis, five times dysentery, four times infectious rheumatism ; twice rheumatic fever had existed with "query" syphilis.

The parents generally become insane in old age, and five times out of nine the illness is described as an evident senile condition. Paranoia and chronic mania have been the other conditions present. A similarity of character is often to be found in the parents and the children. A paranoic father has a daughter suffering from dementia paranoides. But the demential condition of the children is generally more accentuated than that of the parents. Except for the senile dementia, the parents preserve better memory. The mental condition in brothers and sisters is very similar. A brother under the influence of tubercular infection becomes melancholic and imagines himself persecuted ; his sister nearly at the same age, after confinement, starts a maniacal condition, rapidly ending in a demential state. Both die after one year's illness. There may be a difference between the two diagnoses, but it is obvious that the general pathological condition is the same in its origin, in the constitutional nature of the disease and the poor physical resistance, failing to prevent the onset of a rapid fatal exhaustion.

Three cases of general paralysis were observed on different occasions with symptoms of dementia præcox, thus making the diagnosis difficult in the early stage (No. X, B; XI, A; XI, B). In these cases the neuropathic heredity was heavy. In one case the brother suffered from a typical condition of dementia præcox (X, A). As regards the other cases the mental condition was exactly the same in brothers, in sisters or in mixed siblings.

In the first group (I to IX) relating to parents and children, we shall have to trace the brain pattern of the parents in the bigger and more complex pattern of the children. In the second group (X to XVI) relating to siblings<sup>1</sup>, brothers and sisters, we shall endeavour to find out whether the pattern originating from a like origin has undergone variations or noticeable modifications, and if so, how these have been forthcoming.

For the purpose of reliable comparison it will be necessary to find out the relative proportion of the influence of brain weight and of the influence of the sex, and whether there is a difficulty in eliminating these factors in the demonstration of familial peculiarities.

## (II) QUESTIONS ON THE CONVOLUTIONAL PATTERN.

The nomenclature of Retzius has been followed in this paper; attention has been paid to the remarks of Edgar Schuster. For the occipital pole I have adopted the anterior occipital of Wernicke, and I think there are sufficient reasons for calling attention to an inferior transverse occipital on the inferior surface.

In the case of each pair of brains eighty-three questions came under consideration. The questions and answers have been carefully revised three times over on separate occasions. The complete review of eighty-three questions dealing with thirty-two brains (sixty-four hemispheres) thus require 5,312 answers and is a very lengthy process. Experience obtained by the way yields fresh ideas and in respect of some questions it cannot be denied that a certain factor of personal impressions had its influence, although the comparison resulted in a formula, which always closely approximates to the objective consideration of the facts.

All the answers to the questions mentioned in the following list

<sup>1</sup> Siblings = offsprings of a single pair of parents.

(Table B) had been given with the description of each pair in a special table, the number of a question referring to the number of the subsequent tables. A summary had been added to each description in accordance with Table C.

The general description of the brains was written when the answers to the questions were collected, the table of the answers suggesting more rapidly to the mind the main points to be discussed. Descriptions of the brains have been twice revised. Then the thirty-two brains have been inspected at the same time and each question in the series has been checked; especial attention has been given to those questions which suggested some doubt or discussion, from a morphological point of view. Characteristic parts of the brains have been drawn in projection figures by a control method, and in natural size.

It was only when this preliminary work was done, that the answers were worked out by statistical methods, as will be shown later on. But from that moment not a single further alteration in the tables was allowed, so as to prevent any personal bias influencing the statistical conclusions.

No questions have been put discussing the insula, as it was not advisable to destroy the valuable material, which still can be used for other research work. Should questions be put as to the insula and as to the Heschl convolutions, I suggest the following as the most practical, in my opinion:—

*Is there a sulcus brevis accessorius insulæ?* Referring to the existence of four distinct gyri brevi (Retzius).

*Is the post-central sulcus insulæ divided or not?* (How many pieces?)

*Is the sulcus temporalis transversus divided or not?*

The insula has a very constant configuration and the results of its exploration would remain practically without great importance, as far as I have learned from those brains where it was accessible. But in several hemispheres the insula could not be examined and therefore, and also for the sake of preservation of the material, I have purposely omitted the details as to this subject. Further questions however, can always be put. For example, I did not pay attention to the concealed parts of the opercula; and the operculum frontale seems to be of importance.

TABLE B.—QUESTIONS CONCERNING FISSURES AND SULCI.

A and c	1	Fissura lateralis, number of anterior rami.	
	2	Fissura lateralis, number of posterior rami.	
	3		sulcus præcentralis superior.
	4		sulcus præcentralis inferior.
	5	Sulcus centralis	sulcus postcentralis superior.
	6	+	sulcus postcentralis inferior.
	7	(Anastomoses with)	sulcus subcentralis anterior.
	8		sulcus subcentralis posterior.
	9		fissura lateralis separately.
	10	Sulcus centralis cuts superomesial border.	
Frontal lobe	11	Sulcus præcentralis superior	sulcus præcentralis inferior.
	12	+	sulcus frontalis superior.
	13	Sulcus præcentralis superior divided into two sections.	
	14	Sulcus præcentralis intermedius present.	
	15		sulcus frontalis superior.
	16	Sulcus præcentralis inferior	sulcus frontalis inferior.
	17	+	fissura lateralis.
	18	(Anastomoses with)	sulcus subcentralis anterior.
	19		sulcus diagonalis.
	20	Ramus horizontalis separate.	
	21	Ramus horizontalis + sulcus frontalis medius.	
	22	Sulcus diagonalis well (+) or badly (–) developed.	
	23	Sulcus frontalis superior, number of segments.	
	24	Sulcus frontalis superior, + sulcus frontalis medius.	
	25	Sulcus frontalis mesialis, well developed.	
	26	Sulcus frontalis medius, well developed.	
	27	Sulcus frontalis medius, number of sections.	
	28	Sulcus frontalis inferior, continuous.	
	29	Sulcus frontalis inferior + sulcus diagonalis.	
	30	Sulcus frontalis inferior + sulcus radiatus.	
	31	Sulcus frontalis inferior + sulcus fronto-marginalis.	
	32	Sulcus frontalis marginalis, number of sections.	
	33	Sulcus rostralis superior.	
	34	Sulcus rostralis medius.	
	35	Sulcus rostralis inferior.	
	36	Sulcus rostralis transversus anterior joining sulcus cinguli and antero-mesial border.	
	37	Sulcus orbitalis saggittalis + sulcus orbitalis transversus.	
	38	Sulcus orbitalis transversus, number of pieces.	
	39	Sulcus olfactorius, well (+) or badly developed.	
	40	Sulcus olfactorius, mesial (+) or lateral (–) direction.	

To each question the answer concerning the left hemisphere of the elder brain (A) is put first—let it be “yes” (+) for example; then comes the answer for the left hemisphere of the younger brain (B)—let it again be “yes”; then for the right A; then for the right B. If all the answers are positive, the formula obtained on this manner will be + + + +. If the conditions in brain A are totally different from those stated in brain B, the formula will be

TABLE B—(continued).

Parietal lobe	41		{ Sulcus postcentralis inferior.
	42	Sulcus postcentralis superior	{ Sulcus interparietalis.
	43	+	{ Sulcus parietalis superior.
	44		{ Sulcus interparietalis.
	45	Sulcus postcentralis inferior	{ Sulcus subcentralis posterior.
	46	+	{ Fissura lateralis.
	47	Sulcus interparietalis proprius,	continuous.
	48		{ ramus ascendens sulcus temporalis superior.
	49	Sulcus interparietalis proprius	{ ramus ascendens sulcus temporalis medius.
	50	+	{ sulcus intermedius primus.
	51	(Anastomoses with)	{ sulcus intermedius secundus.
Temporal lobe	52		{ sulcus occipitalis transversus.
	53		{ sulcus parietalis superior.
	54	Sulcus parietalis superior independent.	
	55	Sulcus parietalis superior, number of sections.	
	56	Sulcus parietalis superior + sulcus præcunei.	
	57		{ anterior interruption present.
Temporal lobe	58	Sulcus	{ middle interruption present.
	59	temporalis superior	{ posterior interruption present.
	60	Sulcus temporalis transversus joining sulcus temporalis superior.	
	61	Sulcus temporalis medius, number of sections.	
	62	Sulcus temporalis inferior, number of sections.	
Occipital lobe	63	Sulcus lingualis independent.	
	64	Sulcus occipitalis anterior present.	
	65	Arcus intercuneatus superficial.	
	66	Lobulus parieto-occipitalis present.	
	67	Sulcus occipitalis transversus inferior present.	
	68	Sulcus verticalis continuous with fissura retrocalcarina.	
	69	Sulcus lunatus present.	
	70	Sulcus paramesialis at the lateral surface.	
	71	Sulcus occipitalis medius (lateralis) + a sulcus temporalis.	
	72	Sulcus occipitalis medius continuous.	
	73	Sulcus occipitalis inferior independent.	
Limbic lobe	74	Sulcus rhinicus externus joining the fissura lateralis.	
	75	Sulcus rhinicus internus present.	
	76	Sulcus	{ temporal interruption present.
	77	collateralis	{ fusiform interruption present.
	78		{ lingual interruption present.
	79	Isthmus lobuli limbici concealed.	
	80	Sulcus subparietalis, number of segments.	
	81	Sulcus cinguli, number of segments.	
	82	Sulcus cinguli + sulcus subparietalis.	
	83	Sulcus intralimbicus present.	

+ - + - or - + - +. If the condition in the left hemisphere of A is different from the condition existing in the three other hemispheres, the formula will be - + + + or + - - -. One gets very soon accustomed to such formulæ, and the addition of similar formulæ out of one table of answers is very easy.

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TABLE C.—COMPARISON TABLE FOR HEREDITARY RESEMBLANCES IN THE FURROWS OF THE CEREBRAL HEMISPHERES.

A = the brain of the first-born individual ; B = the brain of the younger.  
Number of questions, 83. + means "Yes" ; - means "No."

*Similarities.*

- 1 Number of cases where the four hemispheres show the same condition.
- 2 Number of cases where three hemispheres show the same condition.
- 3 Number of cases where the two left hemispheres show the same condition.
- 4 Number of cases where the two right hemispheres show the same condition.

*Similarities of Differentiation between the Left and the Right Hemisphere.*

- 5 Cases in which occurs the formula (+ + - -) or (- - + +) ; the two left similar and the two right similar, but the right condition being different from the left condition.

*Peculiarities in one Hemisphere.*

- 6 Number of peculiarities special to left A (- + + +) or (+ - - -).
- 7 Number of peculiarities special to left B (+ - + +) or (- + - -).
- 8 Number of peculiarities special to right A (+ + - +) or (- - + -).
- 9 Number of peculiarities special to right B (+ + + -) or (- - - +).

*Confirmed Dissimilarities.*

- 10 Number of cases where left A is similar to right A and left B to right B (+ - + -) or (- + - +).

*Whether there is Inversion of Similarity.*

- 11 Number of cases where left A is similar to right B and right A to left B (+ - - +) or (- + + -).

*Indexes.*

- 12 Apparent index of similarity, first method  $(1 \times 4) + (2 \times 3) + (5 \times 4) : (10 \times 4)$  in percentage.
- 13 Apparent index of similarity, second method  $(2 + 3) : (10 \times 2)$  in percentage.
- 14 Apparent index of dissimilarity.
- 15 Remnant percentage of variabilities or incomplete similarities (peculiarities and inverted similarities).
- 16 Absolute index of comparison, first method.
- 17 Absolute index of comparison, second method.
- 18 Results of comparison with other brains.

TABLE D.—COMPARISON OF RIGHT AND LEFT HEMISPHERES IN THE SAME BRAIN.

- 1 Number of similarities for the questions concerning the lateral fissure and the central sulcus (10 questions).
- 2 *id.* for the frontal lobes (30 questions).
- 3 *id.* for the parietal lobes (16 questions).
- 4 *id.* for the temporal lobes (6 questions).
- 5 *id.* for the occipital lobes (11 questions).
- 6 *id.* for the limbic lobes (10 questions).
- 7 Total (83 questions).
- 8 Percentage of similarity for the brain.



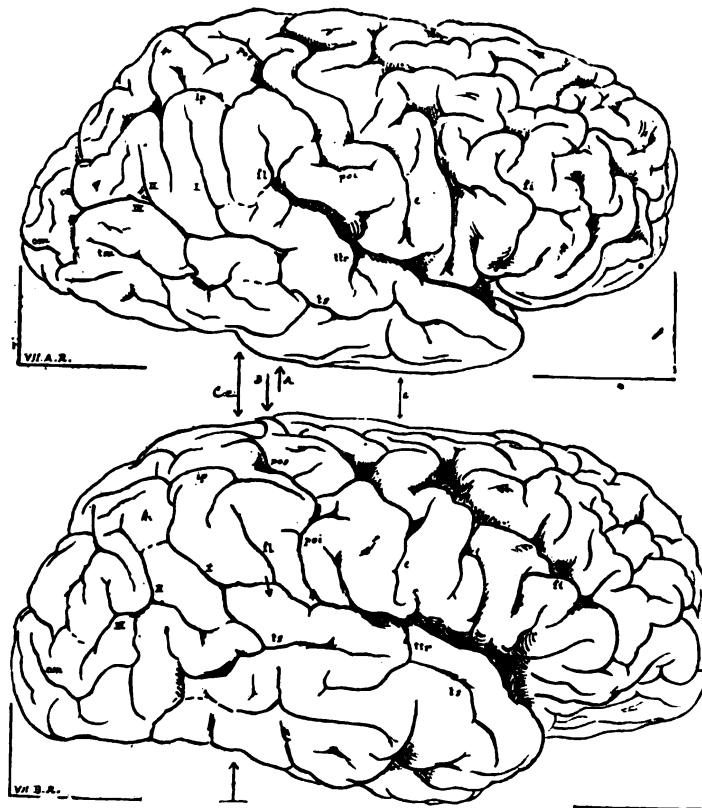


FIG. 1.

Lateral aspect of the two right hemispheres from brain pair VII (mother A and daughter B). In the mother's right hemisphere the inferior frontal sulcus (*fi*) is interrupted, in the daughter's brain it is not. In A the interparietal sulcus (*ip*) is not interrupted and joins the post-central superior (*pos*) and the post-central inferior (*poi*); in B *ip* is interrupted and does not join *pos* + *poi*. In A the superior temporal (*ts*) is not interrupted and does not anastomose with the transverse temporal (*ttr*), which is the case in B. It is the differences which strike the observer at first sight, similarities do not come into evidence so rapidly. A method therefore becomes necessary. These two brains VII A and VII B have but a small number of confirmed dissimilarities. C.c., end of the corpus callosum in both brains; B., superior end of the sulcus centralis in brain B; A, *id.* in brain A.; c, inferior end of sulcus centralis in both brains. The arrow in brain B near the lateral fissure (*fi*) indicates a deep annectent gyrus.

## (III) FIRST RESULTS OF COMPARISON. INDEXES.

When the conclusions of the comparison of the twin brains were stated, I could not compare the results obtained with any others, as it was the first time that an attempt had been made to obtain a number expressing a degree of similarity for relative brains. Indications of any kind failed as to the value of each question for a comparative study, although the percentages of different authors as Retzius, Cunningham, and Eberstaller might have a real value for a general control. The papers of Waldeyer, Spitzka, Karplus and Schuster on relative brains do not arrive at a very definite stage of knowledge. By their most valuable work the problem is clearly put.

With a table summarizing the results, as I have given in my paper on the twin brains, it will be easier to check the actual value of the questions and to improve the method. Perhaps an attempt could be made to simplify the examination and to eliminate some questions, although this would only concern the brains now to hand. For a new series it always will be necessary first to propound a greater number of questions and to reduce their number later on, if it seems suitable or justified by the experience newly acquired.

The method I used for the twins consisted in adding the cases, where four hemispheres were similar, those where three hemispheres were similar and those where the hemispheres were similar to each other on both sides at the same time (Nos. 1 and 2 and 5 of Table C). The sum converted into percentages according to the number of possibilities of a complete resemblance is then divided by the percentage of complete dissimilarities. I have tried to simplify this procedure by taking the sum of the left similarities with the right similarities, reducing them to a percentage and dividing this percentage as in the former method, by the percentage of the complete dissimilarities. It is, of course, not necessary to reduce the numbers to percentages to obtain the index of comparison, but the percentages are necessary for the general consideration, being more easily understood.

The first method confers more importance on the conditions where three hemispheres are similar to each other, as it shows persistence of the common original type. Again attention must be called to our present ignorance as to the reciprocal value of each of the formulæ, which may occur. It seems justifiable to admit that a confirmed differentiation (+ + - - or - - + +) should be of more importance than a complete similarity in the four hemispheres (+ + + + or - - - -) because in

addition to a similarity there is a resemblance of differentiation between the left and right hemisphere, and moreover this is seen far more frequently in relative than in non-relative brains. But it would be premature to state any further estimate of its comparative value. Some indications on the other hand tend to suggest that it is better not to compare the four hemispheres in one formula as by the first method. The inheritance of the right pattern is somewhat different from the inheritance of the left pattern. The percentages of similarity for left and right hemispheres separately have been taken as a first element in the second method. The index of dissimilarity however comprehends the four hemispheres in one result, as it is the only manner of stating a real difference.

TABLE E.—COMPARATIVE INDEXES IN SERIES ACCORDING TO THE FIRST AND TO THE SECOND METHOD.

No. of the Series	No. of the brain pair	Absolute index, first method	No. of the brain pair	Absolute index, second method
1 ...	XVI ...	5.65 ...	XVI ...	4.87
2 ...	XII ...	6.04 ...	III ...	4.35
3 ...	III ...	6.20 ...	XII ...	5.54
4 ...	IV ...	6.32 ...	IV ...	5.60
5 ...	IX ...	6.65 ...	IX ...	6.20
6 ...	XV ...	8.18 ...	II ...	7.42
7 ...	X ...	8.43 ...	XV ...	7.50
8 ...	II ...	9.21 ...	X ...	7.93
9 ...	VI ...	9.60 ...	VI ...	9.00
10 ...	XIV ...	11.14 ...	XIV ...	9.70
11 ...	VII ...	13.00 ...	VII ...	11.40
12 ...	XI ...	13.45 ...	VIII ...	12.20
13 ...	VIII ...	13.90 ...	XI ...	12.30
14 ...	V ...	13.90 ...	V ...	12.40
15 ...	I ...	13.95 ...	I ...	12.60
16 ...	XIII ...	14.00 ...	XIII ...	13.00

N.B.—The differences are very slight and the index figures for the brain pairs remain nearly at the same places. Only in those for Case II is there a serious difference.

In order to facilitate the review of the cases I place them in series according to the two methods in Table E.

Female brains are slightly more similar to one another, about 1 per cent. more, than male brains. Mixed comparisons give the lowest numbers of comparative resemblance; the lessening of the numbers is about 11 per cent. It is to be noted that the brain weight of the females was 12 per cent. less than the average brain weight of the males. There seems to be a correlation between these differences; the disturbance brought about in the comparison by sexual difference seems to correspond to that percentage, but it is not the difference of brain weight only nor chiefly which determines the differences, as

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TABLE F.—AVERAGES OF THE INDEXES OF COMPARISON ACCORDING TO SEXUAL INFLUENCE.

FEMALES COMPARED		MALES COMPARED		MIXED COMPARISONS	
First method	Second method	First method	Second method	First method	Second Method
6.02	5.54	5.65	4.87	6.20	5.35
6.32	5.60	8.43	7.93	8.18	7.50
9.60	9.00	13.45	12.30	6.65	6.20
13.00	11.40	13.95	12.60	9.21	7.42
18.90	12.40	—	—	11.14	9.70
14.00	13.00	—	—	13.90	12.20
Averages : 10.47	9.49	10.37	9.42	9.21	8.06

TABLE G.—AVERAGES IN DESCENDING PARENTAGE.

FATHER AND SON		FATHER AND DAUGHTER		MOTHER AND DAUGHTER		MOTHER AND SON	
First method	Second method	First method	Second method	First method	Second method	First method	Second method
13.95	12.60	9.21	7.42	6.32	5.60	13.90	12.20
—	—	6.20	5.35	13.90	12.40	6.65	6.20
—	—	—	—	9.60	9.00	—	—
—	—	—	—	13.00	11.40	—	—
Averages : 13.95	12.60	7.45	6.38	10.43	9.60	10.27	9.20

General average : First method, 10.30 ; second method, 9.13.

TABLE H.—AVERAGES IN COLLATERAL PARENTAGE.

BROTHER AND BROTHER		SISTER AND SISTER		SISTER AND BROTHER		MALE TWINS	
First method	Second method	First method	Second method	First method	Second method	First method	Second method
8.43	7.93	6.02	5.54	11.14	9.70	5.65	4.87
13.45	12.30	14.00	13.00	8.18	7.50	—	—
Averages : 10.66	9.91	10.01	9.27	10.60	8.35	5.65	4.87

General average : First method, 9.69 ; second method, 8.69.

will be proved in the chapter on sexual differences. Moreover the inherited family resemblance has a greater importance than the sexual differences.

The difference between descending and collateral parentage may be due to the fact that in the first group there are six (i.e., 33 per cent.) male and twelve (77 per cent.) female brains and four mixed comparisons (66 per cent.). In the second group there are eight (57 per cent.) male and six (43 per cent.) female brains and two mixed comparisons (28 per cent.). For a same degree of parentage very different numbers are forthcoming; no conclusions can be stated at present; the four cases of mother and daughter are especially interesting as they exhibit superior as well as inferior numbers.

The indexes obtained for each of the comparisons of relative brains have been put into Diagram I.

It is obvious that, the amount of similarities being nearly the same and varying only in one-seventh of the average number, whereas the number of complete dissimilarity varies in one-half of its own average, the resulting index of comparison is almost a mere function of the amount of dissimilarities.

As a control to those results I have made a great number of comparisons from some of the brains with *non-relative* brains. The next diagram (II) concerns the comparison between the father A of the first pair with his son and the thirty others not related to him, the comparison between the heaviest brain with thirty-one others and with the sister's brain, and the comparison between the negro's brain with thirty others and the mother's brain. The figures show that with respect to these comparisons neither the brain weight nor the sex exhibit an importance comparable to the personal and familial brain pattern. If the brain weight possessed an overwhelming importance, the series would come out according to the weight. If the sex possessed it the series would be according to the sex. If the racial influence had a real individual value, the negro and his mother would be at the beginning of the list, but they stand very far apart from each other. The relative brain of the son, however, comes out at the highest point of similarity with his father's brain.

More will be said about the influence of sex in a special chapter; as to the racial influence we can only review the question in brief, as only two negro brains are at our disposal. The conclusion arrived at in every anthropological research on the brain pattern has been that no peculiar condition whatever exists for one special human group. "Non conosciamo

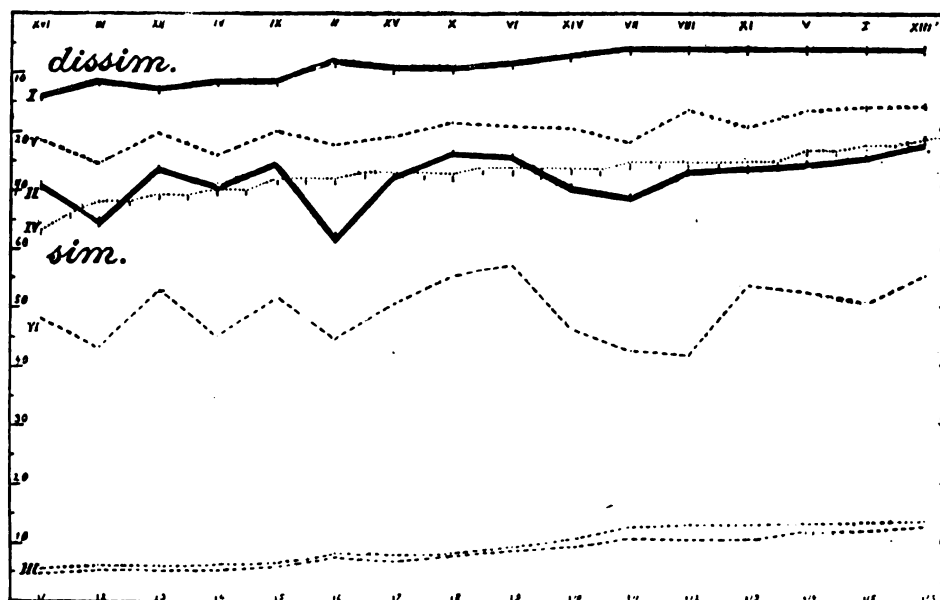


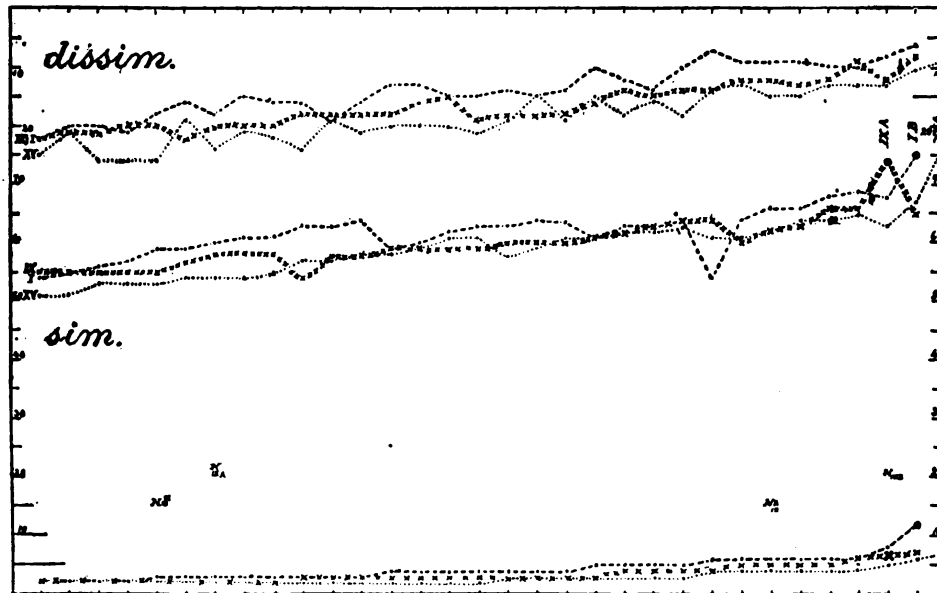
DIAGRAM I.

Comparison of relative brains. Seriation according to the absolute index of comparison.

- (I) Indexes of apparent Dissimilarity (scale beginning from above).
- (II) Indexes of apparent Similarity (second method).
- (III) Absolute Indexes of Comparison (according to the two methods) (not in percentages).
- (IV) Indexes of Similarity by comparison of hemispheres of the same brain.
- (V) Indexes of apparent Similarity (first method).
- (VI) Percentages of cases where the four hemispheres are similar (p. 24).

Scale beginning from below.

The space between the upper border of the diagram and the line (I) contains the complete dissimilarities; the space between (I) and (V) the peculiarities existing only in one out of four hemispheres and the cases of inverted similarity; the space between (V) and (II) contains the cases in which three hemispheres are similar; the space between (II) and the lower border of the diagram contains the similarities, left and right separately considered. Between (VI) and the lower border are the cases in which four hemispheres are similar. The Roman numbers on the upper border refer to the pairs of brains (p. 4). The numbers of the brains have not been given for comparison of hemispheres belonging to the same brain.



[DIAGRAM II.]

Comparison of non-relative brains, in series according to the absolute index of comparison:—

- (I) Comparison of brain 1A with thirty-one other brains, including the son's brain (1B).
- (XV) Comparison of the heaviest brain (XVB) with thirty-one other brains and with the sister's brain (XVA).
- (IX) Comparison of a negro brain (IXB) with thirty other brains and with the mother's brain (IXA).

The lines of dissimilarities with the scale to be read from above.

The lines of similarities (second method) with the scale from below.

The absolute indexes of comparison (no percentage).

The average percentages are:—

		1A		XVB		IXB
Non-relatives	Apparent similarity	62.29	...	58.91	...	59.95
	Incomplete similarity	2.40	...	3.13	...	3.24
	Peculiarities	20.66	...	18.53	...	19.30
	Complete dissimilarity	14.65	...	19.43	...	17.51
Non-relatives' total		60.380				73.0
		2.923				1.9
		19.500				16.9
		17.197				8.2
				Relative brains		

un attributo morfologico della solcatura cerebrale, che sia esclusivo di un dato gruppo umano," writes Sergio Sergi.<sup>1</sup> "Many variations indicate the constant tendency to oscillations and divergencies, but still more important seems to be the tendency to the preservation of some morphological characters in relation to the sexual difference, independent of any ethnical difference."

Those who arrived at too hasty a conclusion in an extremely positive manner were speedily contradicted, and Parker's statement: "The negro brain bears an unmistakably nearer relation to the ape type than does the white," did not meet with any confirmation; quite the contrary: and the valuable work of Kohlbrugge<sup>2</sup> on the Javanese brains is one proof more that every kind of peculiarity in the convolutional pattern is to be found in every human race.

At the first examination of the group of relative brains, I did not know that two of these brains belonged to negroes, and I did not find any condition which allowed for the suspicion. After having duly considered the problem on this occasion, I am led to conclude that, if racial differences exist, as we may expect, it is only the statistical method on a large scale that will be able to render us further help.

Four hundred and ninety-six comparisons are possible with the brains described. When, exceptionally, the index of comparison with a non-relative brain comes out higher than, or approximates to, that of the relative brains, the confirmed differentiations, always more numerous in the relative brains, indicate which are relatives and which not.

*Index of Variability.*—By adding the similarities and the dissimilarities we obtain the amount of fixed characteristics; the remainder is formed by incomplete similarities and by peculiarities; it gives the percentage of *variabilities*, or unfixed characteristics. In all these estimations we are only considering the inheritance of the pattern of *one* parent, which is a preliminary study to that of the combination of both parents' patterns; the material did not allow of the latter being made. The remainder now of so-called variable conditions is smaller in relatives than in non-relatives. The smallest remainder occurred for the first pair (George Smith and his son George Smith), then follows the Negro family, then two old sisters, two Hebrew brothers, the twins, and so on (Diagram III).

<sup>1</sup> Sergio Sergi, "Contributo allo Studio del Lobo Frontale e Parietale nelle Razze umane," *Ricerche, ecc.*, R. Università di Roma, ecc., 1908, xiv, fasc. 1, 2.

<sup>2</sup> Kohlbrugge, "Die Gehirnfurchen der Javanen." Akademie der Wetenschappen, Amsterdam, 1906.



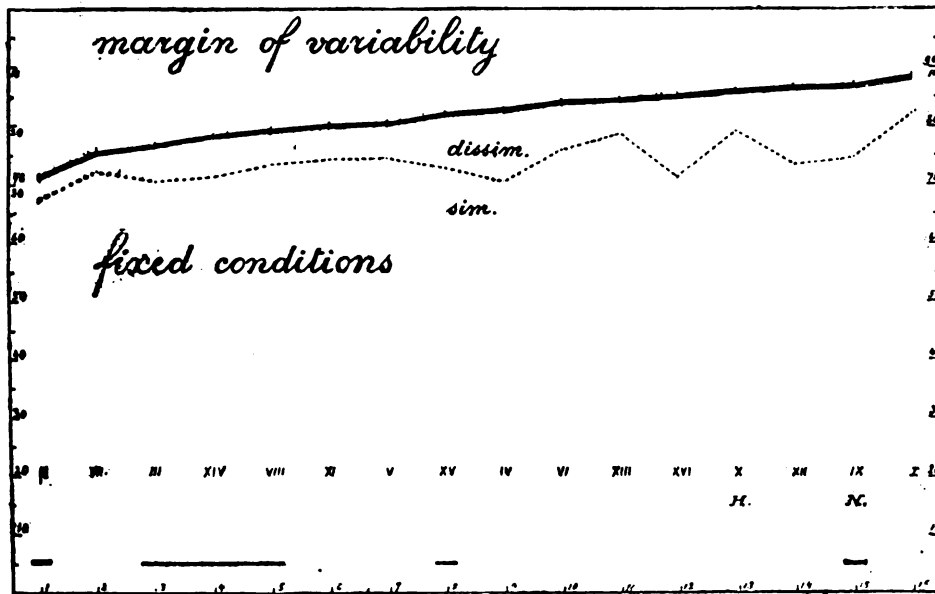


DIAGRAM III.

The margin of variability; seriation according to the index of variability (scale from above). The Roman numbers refer to the pairs of brains (p. 4). N IX are the Negroes, X the Hebrew brothers, XVI the twins. Comparisons of mixed sexes are underlined, according to the second method.

According to the first method the Negroes and the twins show the smallest figures for the remainder of variability. As we do not exactly know the racial origin of our subjects, it is not possible to control if the amount of variability increases with a more mixed racial origin.

There is a tendency for the sexual mixed comparisons to occur on one side of the diagram, and except for the Smith family (I) and the Negroes (IX), five brothers and sisters out of seven collateral comparisons are at the top of the percentage; the two others (brother and sister XIV and sister and brother XV) are mixed comparisons. Thus collateral parentage of the same sex shows less variabilities than descending parentage or than collateral parentage of different sexes.

*Decreasing Similarity in Relative Hemispheres.*—As proved in Diagram I, the apparent similarity between the two hemispheres of a brain is as great as the apparent similarity between the brains of two persons directly related by blood. The index between the two hemispheres of the first examined brain A, I (father) is 0.74. The index for

his left hemisphere compared with the left hemisphere of his son is also 0.74. The index of the father's *left* hemisphere with the *right* one of the son, however, is 0.70. The index of the father's left hemisphere compared with the left of a *non-relative* brain is 0.64, and with the right hemisphere of that non-relative brain is 0.59. As a non-relative brain I took the brain II, A. More examples are easily established by the aid of the tables annexed to each description of a pair of relative brains. This proves that there is a difference between left and right hemispheres *in man*, and that our left hemisphere more resembles the left than the right hemisphere of a non-relative brain. But as the resemblance of the left hemisphere to the right one of a relative brain is greater than that obtained with the right of a non-relative, it also proves that the familial type is to a certain degree common to the *two* hemispheres, and that there may be some Mendelian or Galtonic proportion between the three first terms of the decreasing similarity:

$$\frac{\text{Left father's h.}}{\text{Right father's h.}} = \frac{\text{left father's h.}}{\text{left child's h.}} > \frac{\text{left father's h.}}{\text{right child's h.}} > \frac{\text{left father's h.}}{\text{left non-rel. h.}} > \frac{\text{left father's h.}}{\text{right non-rel. h.}}$$

$$0.74 \qquad \qquad 0.74 \qquad \qquad 0.70 \qquad \qquad 0.64 \qquad \qquad 0.59$$

The equality of the two first terms (0.74 and 0.74) cannot be considered as a case of homotyposis because the third term shows that the father's left hemisphere is not equally similar to the two child's hemispheres. Moreover the whole demonstration clearly shows that each hemisphere of the brain is a *differentiated* organ.

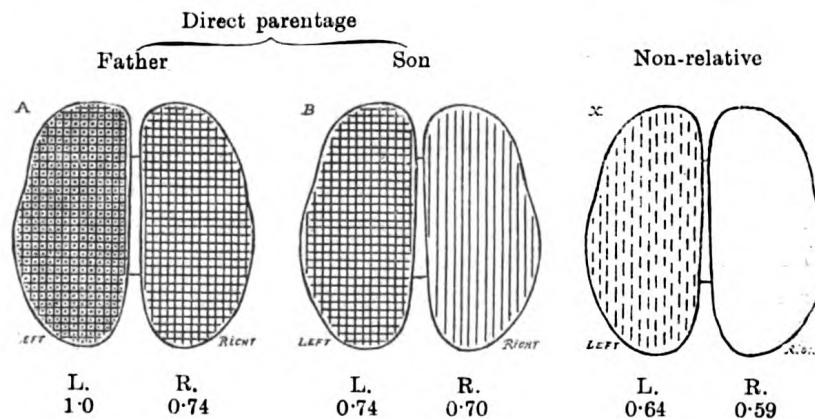


FIG. 2.

Decreasing similarity

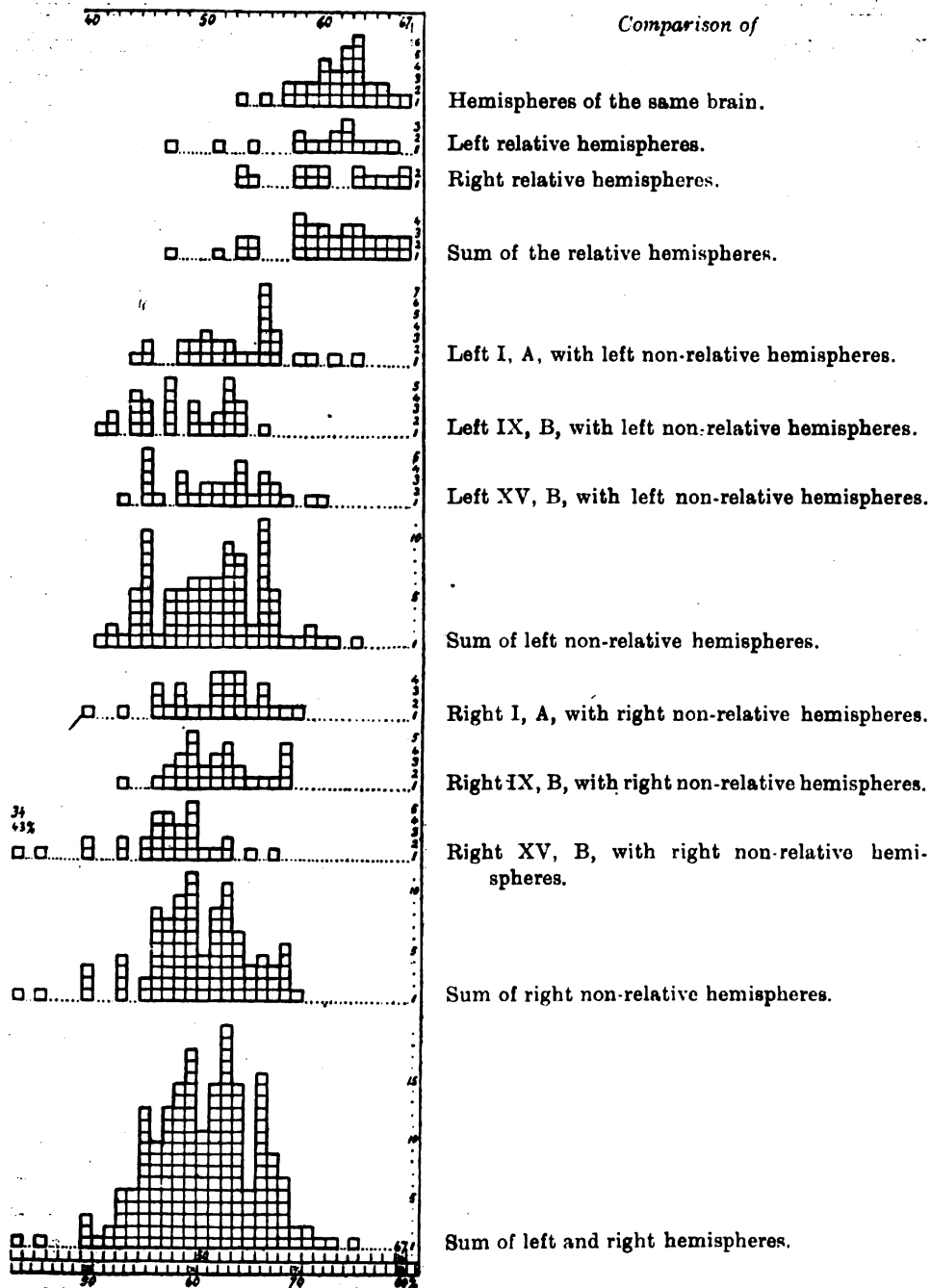


DIAGRAM IV.

Frequency polygons. The diagram is composed of the original numbers of similarity, out of eighty-three questions. The corresponding scale of percentages is added at the lower border of the figure.

All the averages and indexes which I have given are arithmetical means, except the absolute Index of Comparison. They are not to be compared with the ratio or degree of correlation obtained by trigonometric calculations. For instance, when I found that the complete similarity for relative brains corresponds to 0.49, this is an arithmetical mean for the sixteen pairs of brains which I examined and cannot lay claim to be anything more. Some of my tables are capable of being put into frequency polygons, as in Diagram IV. The modal value and the frequency of the modal brains would appear to give a geometrical result, slightly different from the arithmetical result, but I do not think that we can yet calculate it with sufficient accuracy. Fresh indications which appear to be established by this method are as follows:—

(1) The negative standard deviation, indicating the progressive variations, is greater than the positive standard deviation, and this also appears from the figure giving the brain weights of males and females. It proves that the actual pattern of the human brain is forthcoming from a less constant and less similar pattern. It suggests that the ancestors of the present human race had a lower index of comparison than that to be found at present.

(2) The modal value of the similarity in relative brains seems to be a little less and behind the modal value of the similarity between hemispheres of the same brain.

(3) The curve of the totals for the left hemispheres has two summits, owing, as it will be proved further on, to the influence of sexual differences from unequal development of the speech centres, culminating in the left hemisphere.

#### *Conclusions to the Third Chapter.*

The comparison of relative brains has an individual value. In other words, when the convolutional pattern of a series of brains has been described, no indications have been forthcoming until now to determine which of them are the heaviest, nor whether a brain belongs to a male or to a female, nor to which family of the human race it is most likely to belong. But the pattern of a father's brain being given, it is possible to find his child's brain out of a series of non-relative brains.

One hemisphere of a human brain resembles the other hemisphere as much as it resembles the hemisphere of the same side in the parent, the child, or the sibling. But it less resembles the hemisphere of the other side in the family members of direct parentage; still less the

hemisphere of the same side in a non-relative brain, and least of all the hemisphere of the opposite side in a non-relative brain.

The constancy of an hereditary resemblance in the convolutional pattern is thus undoubtedly proved.

#### (IV) DISCUSSION OF THE QUESTIONS.

The same summary (Table C) which has been used for each case of comparison can be used for each question. The figures obtained by this manner have been collected in tables, which show the amount of similarities and dissimilarities, and give an idea of the variability of each part of the convolutional pattern to which the question refers.

TABLE I.—RESULTS SUMMARIZED ACCORDING TO TABLE C, AND GROUPED FOR THE LOBES OF THE HEMISPHERES IN PERCENTAGES.

	Four similarities	Three similarities	Left similarities	Right similarities	Confirmed differentiation	Left peculiarities in A	Left peculiarities in B	Right peculiarities in A	Right peculiarities in B	Complete differences	Inverted similarity
	1	2	3	4	5	6	7	8	9	10	11
<i>Fl and c</i> ...	58	25	75	81	6	8	9	6	5	5	1.9
Frontal lobe ...	57	24	75	75	5	8	6	8	6	8	1.6
Parietal lobe	43	35	72	69	9	7	9	9	10	8	2.7
Temporal lobe	37	42	59	66	4	7	16	13	7	9	3.9
Occipital lobe	45	35	88	81	11	8	6	9	11	8	0.5
Limbic lobe ...	41	31	66	67	9	11	6	8	6	11	2.4
	49.9	30.8	72.8	73.1	7.2	8.5	8.2	9.0	7.9	8.1	1.9
			73.0			16.7		16.9			

*Lobar Differences.*—The central area and the frontal lobes are relatively very constant in their hereditary resemblance. The parietal lobe is a little less similar. The temporal lobe is the most variable, as a result of the differences in the auditory area, always more complex on the left side and showing leading conditions in that side, as it will be demonstrated further on. Peculiarities in the right temporal lobes are numerous, showing that when a condition exists in both hemispheres of one relative brain, this condition will exist on the left side of

the other brain, as a rule, rather than on the right side. The top of the temporal lobe is one of the latest developed and the most advanced extensions of the brain and therefore also the subject of greater variability. The conditions of the occipital lobes are less similar from left to right in the same brain than is the case for the frontal lobes (*see* Table I), but in each pair of left or right hemispheres they show the most constant similarity. The high figures in columns 3, 4 and 5 prove this. The questions relating to the limbic lobe only refer to its boundaries; as a matter of fact the limbic lobe is nearly identical in all the brains, but its boundaries are uninterrupted, or deeply grooved in consequence of the pressure exerted by the development of the others, especially of the temporal lobe. The lower figures for the limbic lobe therefore do not possess that importance which they would have, were they to be found for the questions concerning the structure or form of the lobes themselves.

Some relative brains may be more like one another in the frontal, others in the occipital hemispheres. This also means that the variability may be more or less accentuated in the different lobes. It would be of great interest to follow up the special tendencies in more generations and to bring them into accordance with personal qualities or deficiencies.

(1) *Cases of Four Similarities.*—Questions giving a low number of four similarities relate to conditions undergoing great variability; questions giving a very high number are those referring to exceptional conditions, the rarity of which leave, for most of the brain pairs, a very great number of similarities, without particular significance. It would be of great value to discover conditions which should be exceptional, and at the same time constant in their hereditary transmission, but as far as my series is concerned there is only one example of this sort—namely, the interruption of the calcarine fissure (fig. 3); but there is no proof that this would be constant in other cases. There are 663 cases out of 1,328 giving four similarities—i.e., 49·9 per cent.

(2) *Cases of Three Similarities.*—The number of cases in which three hemispheres are similar is smaller than that in which the four hemispheres are similar, because three similarities mean one peculiarity, and peculiarities are rather exceptions, which exhibit variability. As a general rule it seems evident that the constancy in the brains examined corresponds roughly to 50 per cent. of the morphological characteristics and that the variability corresponds to 30 per cent. But it is also necessary to examine each hemisphere separately, with its homologue in the relative brain. There are 410 cases out of 1,328 giving three similarities—i.e., 30·8 per cent.

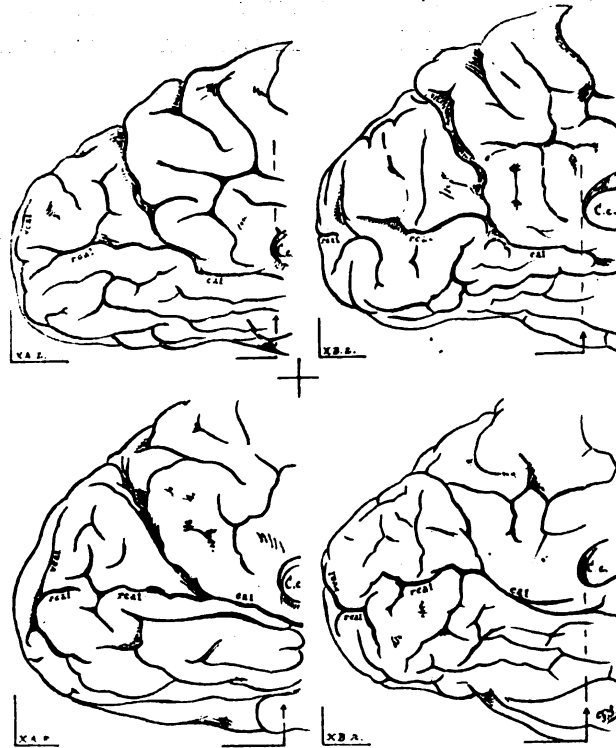


FIG. 3.

**Interruption of the calcarine fissure.** In the four hemispheres of the brain pair (X) the retrocalcarine fissure (*rcal*) was interrupted. The figures of the right occipital poles (mesial aspect) have been given in mirror, so as to make the comparison easy. *Cc*, corpus callosum; *cal*, stem of the calcarine fissure; *rcal*, retrocalcarine part; *vcal*, vertical part. There was no question in Table B about this exceptional condition. It gives one complete similarity more for the two Hebrew brothers.

(3 and 4) *Similarities on the Left and on the Right Hemispheres.*—The number of similarities on the left and on the right hemispheres is nearly the same. It is remarkable how closely the figures 968 and 971 approximate, notwithstanding the very different parts of the brain in which the similarities occur. It shows that there is a constant factor in the possibility of variations as well in the left as in the right hemisphere. The similarity for the whole brain gives 1,939 cases out of 2,656 possibilities—i.e., 73 per cent.

(5) *Confirmed Differentiation.*—The average of similarity being 73 per cent., and that of the confirmed differentiation 7 per cent., we may say that in one-tenth of the similarities there is a differentiation between left and right brain, maintained in the family. It would be

possible to a certain extent to recognize the brains of relatives by these conditions. Brain IX, B, has 12 per cent. such highly expressed similarities with the mother's brain, IX, A, and only two with brain IV, A, the most similar to it. Confirmed differentiations occur for fifty-one different questions, and in every part of the hemispheres. When they occur more than once for a question, the positive answers can be found as well on the right as on the left side; it means that no confirmed differentiation has a constant formula for a special question; for instance, a sulcus intracingulatus is to be found on both left hemispheres four times, with its absence on both right hemispheres, and twice on both right hemispheres, with its absence on the left hemispheres.

Exception is to be made for the question No. 60 (*ttr + ts*). This connexion never exists solely on the right side. When it is on the right it is also on the left. And when there is a confirmed differentiation, the connexion exists on both left hemispheres. That seems to be the result of differentiation in the left verbal auditory area.

(6 and 7) *Peculiarities on the Left Side.*—The results are:—

First group (descending heredity)	...	141 out of 797	=	17.6 per cent.
Second group (collateral heredity)	...	82 ,, 531	=	14.0 ,,
Totals	...	223 ,, 1,328	=	16.9 ,,

(8 and 9) *Peculiarities on the Right Side.*—The results are:—

First group (descending heredity)	...	136 out of 797	=	17.0 per cent.
Second group (collateral heredity)	...	89 ,, 531	=	14.0 ,,
Totals	...	225 ,, 1,328	=	16.9 ,,

Peculiarities mean as a rule variations on a pattern fixed in the three other hemispheres. The number of peculiarities occurring on the left side is nearly the same as it is on the right side. But taking the groups separately, in the left brain the children (B) show a very great variability, which the parents (A) show, but at a lower rate, in the right hemispheres. Seventy-seven questions give peculiarities on the left and seventy-six on the right side. Practically speaking, peculiarities may occur in every part of the convolutional pattern, but never exceed 17 per cent. of the possibilities. They are more frequent when children are compared with one of their parents, than when siblings are compared with one another. Left and right peculiarities together amount to  $16 + 16 = 32$  per cent., which is slightly higher than 30.8 found for No. 2 (three similarities); this



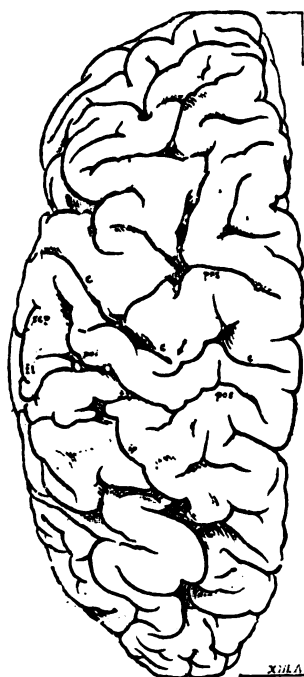


FIG. 4.

Interruption of the central sulcus. Left XIII. A, superior aspect, c, central sulcus (the arrow indicates its interruption): *prs*, sulcus præcentralis superior; *pos*, sulcus postcentralis superior; *poi*, sulcus postcentralis inferior; *ip*, sulcus interparietalis; *scp*, sulcus subcentralis posterior; *fl*, fissura lateralis. There was no question in Table B about this rare peculiarity.

results from some conditions, in which numbers have been taken instead of the signs plus and minus; more than one peculiarity have been obtained for the same question, where a case of three similarities was lost.

(10) *Complete Dissimilarity*.—One hundred and nine cases out of 1,328 give 8·2 per cent. of complete dissimilarities. The number of complete dissimilarities to be found in comparisons of six couples of different sexes (father and daughter, mother and son, sister and brother, i.e., 37·5 per cent. of the cases) corresponds to 40·1 per cent. of the total cases of complete dissimilarities. In ten couples of similar sexes, i.e., 62·5 per cent., the amount of dissimilarities is 59·8 per cent. The amount of dissimilarities is thus slightly greater for the group of dissimilar sexes. But sexual influence, as a rule, is not very marked. An exception seems to exist in the case of No. 24, where the difference is clearly in favour of the sexual influence (*see* § VII). For the questions 16 and 21 the influence of the brain weight is the only efficient factor. For question 35 brain weight and sex combine. The differences in cases of similar sex are directly determined by the weight of the brain and exist especially in the association areas. The development of the central region in a bigger brain brings the ramus horizontalis nearer to the sulcus frontalis medius, and by this means

effects their junction; moreover, the sulcus frontalis medius is better developed in bigger brains. The same result occurs in the case of the sulcus postcentralis superior, which joins the parietalis superior, and the latter, increasing in importance, is divided into two portions. In the lower part of the central region the same development again brings the sulcus diagonalis into closer connexion with the sulcus frontalis inferior, or the præcentralis inferior in conjunction with the frontalis inferior. A larger development of the frontal lobe brings about a good sulcus frontalis mesialis, or a good frontalis medius, sometimes both together. A third sulcus rostralis becomes more frequent (especially in males). The development of the temporal pole causes the interruptions of the superior temporal sulcus to be more frequent.

			Present		Index of similarity		Complete differences		Index of the question
59)	Sulcus	{Posterior interruption	7	...	0.84	...	—	...	27
58)	temporalis	{Middle „	34	...	0.59	...	0.12	...	5
57)	superior	{Anterior „	34	...	0.56	...	0.18	...	3

In the foetal brain, the superior temporal sulcus develops first in its posterior part; its posterior interruption is the least frequent, and gives the least number of variabilities; then comes the middle interruption, and late in foetal life, or even after birth, the anterior part develops, and therefore as variability has more chance of arising, *similarity decreases*.

Differences in the occipital lobe seem to be independent of sex, or brain weight, but are more under the influence of the family and individual complexity of the brain pattern.

(11) *Inverted Similarity*.—Inverted similarities, when the left condition of A resembles the right of B, and at the same time the right A resembles the left B, are rather exceptions in comparisons of relative brains. This rarity lends support to the conclusion that similarities and dissimilarities are facts of morphologic value. If they were results of pure hazard, without any relation to biological factors, inverted similarities would occur as much as confirmed dissimilarities and as total similarities. Before arriving at any conclusion as to any further significance of inverted similarities, it would be necessary to have the brains of both parents of the child examined. Only twenty-six cases out of 1,328 give inverted similarity, i.e., 1.9 per cent.

*Reduction of the Questions*.—An attempt may be made to reduce the number of the questions, to eliminate those which are of less value for the general description of the convolutional pattern. A number of these questions, referring to exceptional conditions, exercise only a moderate

influence upon the final result, and it may be assumed that they rather confuse it in an amount of indifferent answers. Therefore, I made some experiments, eliminating the questions which give fifteen and sixteen similarities in the hemispheres of the left or on the right side, eliminating also questions giving less than ten similarities on one side. The number of questions was thus reduced to forty-eight, but the indexes obtained were not satisfactory, and it was moreover evident that this method of performance did not eliminate a corresponding number of complete dissimilarities. It clearly appeared that for comparisons of non-relatives, the dissimilarities do not occur more frequently in the questions, which give a low number of similarities than in those giving a high number of similarities. I thus came to the conclusion that in the present conditions of our knowledge as to relative brains, *it is still better to increase than to reduce the number of the questions.*

#### (V) ON SEXUAL DIFFERENCES.

Up to now we have found two conditions in which sexual differences could be accounted for. There is the well-known influence on the brain weight. The average numbers were 1,297 grm. for the males and 1,130 grm. for the females. These figures are reduced by the method of hardening, but preserve a comparative value. For fifty-six male brains and fifty-six female brains, taken fresh as they were removed at the post-mortem room shortly after death, and coming from the same asylum population, I found the following numbers, carefully controlled: For the male brains, 1,385 grm.; for the female brains, 1,200 grm. For the series of the relative brains the figures do not extend much more for the males than for the females, but the numbers are low and different (twelve males, eighteen females). When larger numbers are taken, it appears that the variability of the weight is greater in males than it is in females.

A second difference was found for the connexion between the superior frontal sulcus and the middle frontal sulcus. In each of three cases the male had no anastomosis, where the female gave one on both frontal sides; a case of discrepancy occurred for the twin brains, where the bigger brain acts as a male and the smaller as a female, if one may say so. For thirty-two positive answers about this anastomosis ( $fs + fm$ ), thirteen—i.e., 40.6 per cent.—belong to seventy-four—i.e., 43 per cent. males and nineteen—i.e., 59.3 per cent.—belong to eighteen—i.e., 56.2 per cent.—females, showing that indifferent types lessen the

special difference of well-accentuated types; but only one woman, XIII, B, has her two lobes free from this anastomosis, where five males (VIII, B; III, A; XIV A; XV, B; XVI, B), remain completely free from it. Although it might be considered as a result of a bigger brain, that the connexion is wanting in males, the case of III, B, the daughter, who had a bigger brain than her father, does not confirm that hypothesis, the father exhibiting the lack of anastomosis and the daughter not.

Measurements may show that the male brains have a comparatively broader frontal development, and thus explain the origin of this tendency to sexual difference. I have no figures for this control.

In four out of five cases the female brain showed lack of anastomosis in the right hemisphere. In four out of five cases the male brain showed lack of anastomosis in the left hemisphere. Thus the left hemisphere affords the best indications of this sexual difference. The male character exists in 64 per cent. of the male cases, the female character in 88 per cent. of the female cases. This difference is not confirmed by the percentages of Retzius, but the main sexual differences in Retzius's numbers also exist in the middle frontal sulcus, which is twice as much interrupted in males as in females. Possibly a difference of interpretation is the cause of our discrepancy, and thus the conclusions approximate to one another more than appears at first sight.

To discover further sexual differences it is advisable to check in the case of each question the number of positive answers in males as compared with those of the females. Cunningham thinks that the sulcus centralis begins with two portions, but that the sulcus præcentralis superior and the sulcus præcentralis inferior have a common origin and are separated by an annectent gyrus of later development. The figures of my series, although very small, lend support to that hypothesis, as the male brains, being larger and generally more evolved, show only 7 per cent. remnants of continuity, the female brains showing it in 22 per cent. of the cases. The figures of Retzius are very different, males showing 27 anastomoses per cent. and females only 21 per cent.; the right female hemispheres did not show any anastomosis. Nevertheless the average results of Retzius are still lower than those of Cunningham (32 per cent.), and Eberstaller (24 per cent.). Mine are the lowest, although the series relates to small brains and degenerated individuals, in the case of half of them at least. It is possible that racial differences intervene here. The ramus horizontalis of the frontalis medius remains more frequently isolated in males.

The two former conditions, separation of *prs* and *pri* and independence

of *h*, may be considered as the result of an increase of brain substance on the surface and as a consequence of the tendency of isolation of the sulci concerned. But the ultimate result of such an increase of cortex in the central region ends in the concealment of cortical substance, and the anastomosis of the sulci in other places, as it is generally admitted. One may also suggest that the concealment and the anastomosis indicate earlier maturation and fixation of primitive regions, which become fixed before the further development of the cortex allow the convexity of the gyri to extend more widely, and the sulci existing on their surface, such as *h*, to remain separate. Four connexions of the central sulcus and two more in the immediate boundaries of the central region point to a greater complexity of that part of the male brain from the increase of concealed cortex (4, 5, 8, 6). No. 15 is quite an exceptional condition, occurring in only one out of the sixty-nine hemispheres.

The sulci rostrales are more developed in the male brains and the fusiform hypocampic annectent gyrus also exists more frequently in these brains. It may be correlated with the physiology of smell and genetic associations.<sup>1</sup> In three female cases, and in the smallest of the twins, there was only one sulcus rostralis sagittalis.

TABLE J.—ANASTOMOSIS OF THE TRANSVERSE TEMPORAL WITH THE SUPERIOR TEMPORAL.

		L.	L.	R.	R.		
I	Father and son	...	+	+	-	- both on left side.	
II	Father and daughter	...	+	-	+	- the father on both sides.	
III	Father and daughter	...	-	+	-	- the daughter on left side.	
VII	Mother and daughter	...	-	+	-	+	- the daughter on both sides.
VIII	Mother and son	...	+	+	-	+	- son on both sides, mother on left side.
X	Brother and brother	...	+	+	-	+	- B on both sides, A on left side.
XIV	Brother and sister	...	+	-	-	-	- brother on left side.
XVI	Twin brothers	...	+	+	-	-	- both on left side.
	Totals	...	6	6	1	3	

Males: Left, 9; right, 3. Females: Left 3; right, 1.

The further extension of the temporal transverse sulcus and its connexion with the superior temporal gives the most remarkable figures, showing that this connexion exists more frequently in males, and in each sex three times more in the left hemisphere in relation, as we may understand, with the development of the præ-Sylvian region.

<sup>1</sup> This hypothesis was stated in writing, when Professor Springthorpe, of Melbourne, visited the laboratory and told me he had localized the cerebral genetic centre in the lower parts of the frontal lobes. (Handbook for Therapeutics, &c.)

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Some closer details will therefore illustrate this question, the importance of which results from the fact that the transverse temporal is often only indicated in primates, and may be undoubtedly considered as a sign of higher evolution (*see* Table J).

This is a morphological demonstration of the localization of more evolved development in the specialized auditory region of the left hemisphere correlated with the physiology of speech, and it illustrates the general view of Turner, quoted in the introduction of this study.

Another proof is to be found in the comparison of the hemispheres of the same brain one with another. The comparisons have been summarized for each lobe in each brain. Male brains have been united in totals separately from the female brains. The result shows that there is a rate of differentiation between the left and right hemispheres in the same brain, nearly the same as the total variability between one family member and another. When, however, the differentiation is concentrated upon the conditions of one lobe, the other lobes remain more similar. In the male brain the differentiation exists, especially in the temporal and limbic lobes, but for the latter it is an indirect result of the development of the temporal cortex as the questions refer to the boundaries of the limbic lobe, which are under the direct influence of the temporal cortical development and pressure. The receptive area of speech associations being more developed in the left hemisphere in man, appears to be one of the main origins of this sexual difference.

An attempt has been made to discover whether some conditions show more constant similarity in females than in males, and vice versa, in other words, whether the mother is not prepotent for the female characteristics of her pattern, which is to be inherited by her daughter, &c. The figures were too small to allow any conclusion being drawn.

As far as I can gather, the typical male brain should have:—

- (1) Well-developed speech centres: a broad frontal lobe.
- (2) Three, at least two, sulci rostrales, on both sides; no connexion between *fs* and *fm* on the left hemisphere, at least; a well-formed *fms* or a good *fm*, sometimes both together on both sides; an interrupted *fi* in the left hemisphere; an anastomosis of *ttr* with *ts*, in the left hemisphere; and *rhi* joining *fl* and *col* in the left hemisphere.
- (3) Comparing the hemispheres of the same brain with one another, the greater number of differences will occur in the speech centres in males, especially in the temporal lobe and its boundaries near the limbic lobe.

The typical female brain should show the contrary ; with only one sulcus rostralis and connexion between the superior frontal (*fs*) and the middle frontal (*fm*), &c.

These indications do not permit of distinguishing with certainty a male from a female human brain, and the formula of their approximative value cannot yet be given.

(VI) THE RESULTS COMPARED WITH THOSE OBTAINED BY OTHER  
AUTHORS, AND MORE DEDUCTIONS.

If the object of these investigations were merely to demonstrate that there is a resemblance in the convolutional patterns in relative brains, they would even thus possess an interest as a formal proof of the morphological value of some details and peculiarities of the sulci and gyri. The first paper published by Karplus seems to have had that demonstration as its chief aim.<sup>1</sup> I could not obtain access to it in the libraries in London, and had to rely on Schuster's paper, which also proves the existing resemblance. Moreover, I possessed an abundant material, more interesting by itself than any bibliographical research, and only after having studied it thoroughly for some months I was inclined to review the bibliographical aspect of the question. My own work was then finished, and there was no possibility of further modification of it.

Spitzka was the first to describe three adult relative brains of brothers with precision and interesting details. He demonstrated their great resemblance and made some measurements, the most striking result of which shows that the corpus callosum had the same width, notwithstanding the differences in weight of the brains. In some of the brain pairs, which I have examined and which were available for such research, the same similarity exists.<sup>2</sup>

I am indebted to the kindness of Professor Ariëns Kappers, the Director of the Brain Institute at Amsterdam, for the opportunity of inspecting two papers, the contents of which I shall now discuss. In his second study on the inheritance and the variability of the convolutional pattern, Karplus calls attention to his former work.<sup>3</sup> He examined twenty pairs of relatives, five groups of three relatives, and

<sup>1</sup> Karplus, J. P. "Ueber Familienähnlichkeiten," &c., *Arch. Neur. Inst. Oberst.*, Wien, 1905, p. 1.

<sup>2</sup> Spitzka. "Hereditary Resemblance in the Brains of Three Brothers." *Amer. Anthropol.*, 1904, vi (to be found in the Library of the Royal Anthropological Society).

<sup>3</sup> Karplus, J. P. "Variabilität u. Vererbung am Centralnervensystem," Wien, 1907.

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one group of five relatives. For some of these cases the spinal cord only was available. In the majority one or more of the relatives were foetuses or new-born children; he had ten pairs of twins. He came to the conclusion that in the human species the inheritance of the convolutional pattern is a proved fact.

An excellent example was afforded by a series of three relative brains (mother, daughter and son), all of whom had the left hemisphere far less fissured and complete than the right hemisphere, although the three individuals were right-handed (Group XXVI). A peculiarity occurring in a relative brain on the left hemisphere will always, when inherited, occur on the same side in the other family members (*gleichseitige Uebertragung*, homologous transmission). Karplus here refers to conditions which are exceptions in the human brain, and which give low percentages as to their presence in the average pattern. (The peculiarities of which I have given statistics are those conditions which exist only in one hemisphere out of four in which the comparison was made.)

Karplus has made some measurements; he thinks individual variability covers to some extent the familial common type. He has also examined the medulla and the spinal cord in some pairs of relatives and has found family resemblances. Karplus then examined brains of *Macacus rhesus* (four pairs), of dogs (four groups of four, five, three, and three offsprings, and each time the mother), of cats (four groups of four, four, three and four kittens, and the mother cat for each of the groups) of goats (two she-goats and their twins, and a third pair of twins). He found that the family resemblance was *less* in the ape than in the dog and cat families. In the cat and dog the familial type and the peculiarities were inherited to some extent. In the macacus there was such a variability in the arrangement of the sulci that no definite similarity could possibly be noticed.

"The macacus brain shows a great variability of its sulci; some parts of the brain have a greater variability than others (occipital pole); undoubtedly the varieties of the sulci show a very great and striking identity in the two hemispheres of the same brain, but on the other hand, only for one single definite variety could a similarity between mother and offspring be observed" (pp. 71 and 160).

"The brain of the dog shows a great variability. The two hemispheres of the same brain are very similar. Peculiarities occur very often repeatedly in the same family. The two hemispheres of the same brain being very similar there is no occasion to find an homologous transmission" (p. 108).



From the brain of the cat the same conclusions were drawn as from the dog's brain (p. 137). In the goat's brain the variability was extreme, no similarity was to be found between the two hemispheres of the same brain, nor could any familial similarity be determined (Karplus reserves his opinion).

The human brain shows greater differentiation between left and right hemispheres than do the brain of the macacus, of the dog, and of the cat. The familial resemblance and the familial peculiarities are more numerous in the cat and in the dog than in the macacus. But the human brain shows the greatest familial resemblance, and the two hemispheres being differentiated, peculiarities may occur on one side only, and when transmitted by inheritance they will always reappear on the same side.

The macacus seems to be in the phylogenetic development of its zoological order, far behind the place occupied by the dog and the cat, which are at the summit of the carnivora. It would be interesting to examine less developed carnivora. Karplus thinks that it is possible to determine which are the more newly developed parts of the brain by the greater variability in their convolutional pattern. The same may be said for the spinal cord, where familial resemblance is less observed in the newer developed parts (pyramidal tracts) than in the older.

With the observations of Karplus as to the differentiation of left and right brain I fully agree, and I have given numbers to fix the opinions. With regard to the homologous transmission, I especially found this confirmed for the anastomosis of the transverse temporal with the superior temporal. The fact that inverted similarity only occurs in 1 per cent. of the cases also confirms the views of Karplus on the homologous transmission, although it shows that there may be exceptions. Neither Karplus nor myself have had the father and the mother examined with their child, and this would be necessary to make the demonstration complete. I have also demonstrated by many examples the possibility of determining by the degree or the index of variability which are the older parts of the brain. Also, for a sulcus, its similarity decreases in the latest developed parts. I demonstrated this in the case of the superior temporal, the posterior portion of which is the oldest and has twenty-seven for index of comparison, the middle portion five, the anterior portion three. On sixteen comparisons no complete differences (for the interruption) occurred in the posterior part, two occurred for the middle and three for the anterior part.

Juljusz Morawski examined cat and dog families and did not find

the same results as those quoted by Karplus. He found the most contradictory indications. No influence of sex could be traced. The brain weight had some influence on the advancement of the pattern; the body weight had no influence. Unilateral peculiarities were to be found in some cases. Morawski could not find any familial pattern transmitted by inheritance. The only positive fact he was enabled to observe was that some families showed a great number of peculiarities, other families no peculiarities at all.<sup>1</sup> This negative work need not cause any astonishment. Even if twenty observers had confirmed the findings of Karplus, a twenty-first would have been forthcoming to contradict them. This happens in the case of every scientific research and depends upon personal bias. In the present case, instead of being the twenty-first, Morawski was only the third. But he did his work in the laboratory of Karplus. His material was really too poor for the investigation of such a question, and it did not at all possess the value necessary for an experimental control. It would have been better had he examined grandparents, parents and offspring of one cat or one dog family, whereas, he always selected only the mother and the offspring. But this is not the time for discussing experimental methods, and I return to the discussion of human brains, the material of which, although not dependent on a selection, is proved to be of greater value and easier of examination.

Neither Karplus nor Schuster attempted to see whether it would be possible to discover, out of a group of brains, those which show the greatest resemblance and whether they belong to relatives. I cannot claim to have obtained that absolute proof of the familial resemblance, but I think that I have come nearer to obtaining it than my predecessors, as I have indicated the method of finding, out of a group of brains, that one which practically bears most resemblance to a given brain and therefore would have the greatest chance of being related to it.

Out of the series of thirty-two brains under my observation, the method which I had proposed one year ago showed for each brain its related companion of misfortune! Karplus had said:—

"It would be unreliable to give a numerical indication on the degree of similarity, as our knowledge of the variations of the sulci is still too incomplete, and as the statement of the authors on that subject are too much at variance" (p. 33).

<sup>1</sup> Morawski, Juliusz. "Gehirnuntersuchungen bei Katzen- und Hundefamilien," *Jahrb. f. Psych. u. Neur.*, Leipz. u. Wien, 1912, xxxiii, p. 306.

The trial of them which has been made in this paper shows, in my opinion, that arithmetical methods have already yielded such results as to indicate fresh lines for further research and to encourage and justify the prosecution of similar studies. The curves obtained for the answers to the principal questions show that their number is sufficient for the proposed examination. The regularity with which some averages, as, for instance, that of similarity, recur, is a proof of their constancy. Even with fifty-two questions alone, following the tables of Schuster, the figure 0.70 was obtained for the twin brains in my first paper. As a proof of accuracy I ask leave to recall that, having recorded 5,312 answers, I found out of them 968 similarities on the left hemispheres and 971 on the right hemispheres. The number of peculiarities on the left side, thus combining the conditions of the four hemispheres in each question, gave 223 and it was 225 for the right hemispheres.

In his most valuable studies on "The Law of Inheritance of the Mental and Moral characteristics in Man and its comparison with the Inheritance of the Physical Characters," Professor Karl Pearson arrives at a degree of resemblance of 0.5 for direct relationship. In another of his papers we find the following figures for the intellectual resemblance by sibship:—

Male and male	...	...	...	0.46	} degree of resemblance.
Female and female	...	...	...	0.47	
Male and female	...	...	...	0.44	

In his "Grammar of Science" (1900), he had written:—

"The intensity of parental correlation is about 0.3 to 0.5, of grandparental about 0.15 to 0.3, and of fraternal about 0.4 to 0.6, the latter correlation being somewhat reduced when the "fraternity" consists of members of opposite sexes" (p. 459).

Such figures indicate the tangent of the angle which the line in correlation diagrams makes with the  $x$  axis. They are not to be compared with mine. Still, it is interesting to point out that the average of absolute similarity (+ + + +) between two relative brains was found to be 0.5, and that the absolute indexes of comparison gave:—

Male and male	...	...	...	9.42	} index of comparison,
Female and female	...	...	...	9.49	
Male and female	..	...	...	8.06	

yielding thus final results approximating to those of Professor Pearson,

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males being a little less similar than females and mixed comparisons giving the smallest figures.

The reason why I call the index of similarity an *apparent* index ought to be explained. The average of similarities amounting to 73 per cent., the remnant of 27 per cent. contains:—

(XI) incomplete similarities (as + - - +)	...	...	...	1, 9
(VI, VII, VIII, IX) peculiarities (as - + + +)	...	...	...	16, 9
(X) complete dissimilarities (as + - + -)	...	...	...	8, 2

Only the complete dissimilarities are to be taken as a term diminishing the value of the apparent similarities, as the peculiarities and the incomplete similarities contain potential possibilities of similarity, which heredity is capable of bringing about. It is a similarity for two hemispheres that the amount of their power of variability (which we may suppose to be correlated with adaptability) is the same; but we should be only able to measure it by the examination of a large series of brains belonging to one family, which is practically impossible at the present time. It is thus not possible to have a better estimation for an absolute index of comparison than to divide the similarities by the dissimilarities; the resulting figure shows how many times two brains more closely resemble than differ from one another. Next to that, the main attention must be concentrated on the number of conditions in which the two brains show a similarity of differentiation between left and right hemispheres.

The importance of the morphological inheritance of the sulci being proved, the significance of transitory forms becomes interesting. In many of the drawings the slow transition from one extreme condition to another is clearly to be followed up. This is especially the case in the lower end of the central sulcus—adjoining the lateral fissure or remaining remote from it—having an anterior or a posterior direction, and so on; in the connexions of the temporal transverse sulcus with the temporal superior and in the anastomoses of the ascending branches of the temporal sulci with the interparietal; in the different forms of the calcarine fissure, especially at its end, with the *play* of the sulcus lunatus. The significance of the deep gyri can also be traced as they become more superficial, when the brain mass or its complex fissuring augments. They may also be the result of the concealment of cortex when deeply compressed owing to the development of the neighbouring structures. The first method of origin gives the annectent gyri sectioning the inferior frontal sulcus, the interparietal sulcus and the

calcarine fissure. The second method concerns the cortex near to the sulcus diagonalis, the cortex between the two first temporal endings in the gyrus angularis, &c.

From some brains one derives the impression that an early condition of hydrocephalus has kept the sulci apart, preventing their anastomosis or making a normal extension inadequate to the intrinsic structure. Such an influence seems to be especially operative at the posterior end of the lateral fissure and its surroundings, near to the centre of the parietal bones, where the largest diameter exists in hydrocephalic skulls. It may cause the first temporal to be interrupted at its posterior portion. This occurred five times in my series, always confined to the left hemisphere, always in the children, four times in the bigger brains. The brain weight of the case in which it occurred in the smallest can be explained (XIV, B); it must have been higher during life; the brother's brain had a weight of 1,385 grm. It cannot be accurately estimated whether the female brain was more over the average than the male brain. The smallest of the brains showing that condition belonged to one out of six deaf and dumb children.

The cases are: III, B (deaf and dumb daughter); VII, B, adolescent insanity, daughter; VIII, B, son, early melancholia; XIV, B, sister, early mania; XVI, B, stillborn twin. The percentages of Retzius are 21 for the males (12 on the right, 27 on the left), and 4 for the females (8 on the right, 0 on the left). It diminishes the value of my explanation and makes further investigations necessary. Moreover, in the case of this interesting condition, the transitions are frequent and clinical notes do not supply details relating to the early years of the patients' lives nor as to the conditions in which they were born.

As for the general question of heredity, the convolutional pattern shows far more often slight transitions than suddenly appearing differences. Lamarck would find his theories confirmed and Weismann rather the reverse.

The knowledge of the different anastomoses and peculiarities of the sulci in the human brain is not yet based upon as great a number of investigations as the newer methods of biology would demand, and this is easily demonstrated by the comparison of the different numbers found by Cunningham, Retzius, Eberstaller and others. But a comparison with the statistics now at hand can nevertheless supply some indications of interest. Comparing the average figures of Retzius that yield the greatest differences with those of this study, we find that in all the cases, except in two, the figures resulting from the brains of our series indicate

a lack of annectent gyri and consequently a greater number of anastomoses of the sulci with each other. The normal brains described by Retzius had a heavier weight than that of ours, and it may be suggested that this factor is the main reason for the differences; but something more than this influences the figures. Differences relating to the parietalis superior may result from a different interpretation, especially when the parietalis superior is divided into two or more portions. What I considered as part of the *ps* joined with *pos*, may have been considered by others to be a mere secondary branch of *pos*. The same doubt arises in respect of the branches of the interparietal. The differences in the anastomoses of *ps* with the sulci præcunei gives less occasion for misinterpretations and confirm the opinion that heavier brains show a greater number of interruptions. The difference as regards question No. 74 arises from the manner in which the question has been put. Retzius asks for evidence of the existence of the rhinal sulcus, where I have thought that it is more important to look for its anastomosis with the lateral fissure. The concealment of the isthmus, no doubt being here possible, seems to be more frequent in series of lunatics, especially in males.

The statistics of Retzius relate to 100 hemispheres, seventy-five of which were of male and twenty-five of female brains. To make the comparison possible I have made the general percentage for Retzius's as well as for my cases, half of the male and the female percentages. Retzius's original general percentage in fact concerns an unequal mixture of male and female hemispheres. But I quite agree also that the newly given total averages may easily be subjected to criticism. All this proves how necessary it is to review these questions on the basis of a fresh array of carefully collected normal brains. Retzius makes interesting statements relating to the *sulcus interparietalis proprius* and shows that its connexions with the sulci postcentrales supply the following possibilities:—

TABLE K.—ANTERIOR CONNEXIONS OF THE INTERPARIETAL SULCUS.

Form of the connexion :	pos poi	ip	—	—	—	—
Percentage of its existence in the Retzius series	55	17	11	9	4	4
Percentage of Cunningham	60	12	19	6·9	—	—
Percentage in my series	54	9	6	7	18	3
Notation ...	a	b	c	d	e	f

If we assign the initials a, b, c, d, e, f, to each of the modalities, and first write the initial corresponding to the left hemisphere of a brain, and then that corresponding to the right side, each brain will have its formula. The following table shows the inheritance of the different types :—

TABLE L.—DIRECT DESCENDING HEREDITY.

	I	II	III	IV	V	VI	VII	VIII	IX
Father	... af	... ee	... aa	...	...	...	...	...	...
Mother	...	...	...	eb	... ee	... ae	... aa	... aa	... aa
Son	... ee	...	...	...	...	...	...	ca	... bd
Daughter	...	... ad	... da	... ea	... aa	... aa	... ab	...	...

TABLE M.—DIRECT COLLATERAL HEREDITY (SIBSHIP).

	X	XI	XII	XIII	XIV	XV	XVI
Brother	... fa	... ae	...	...	ba	...	ea
Sister	...	...	aa	... aa	ca	... db	...
Brother	... ea	... aa	...	...	...	bd	cc
Sister	...	...	aa	... aa	...	...	...

The older brain has been put first. The formulæ in italics belong to the brains showing the posterior interruption of the superior temporal. The most common type seems to be *a*, eleven brains out of thirty-two have the formula *aa*; nine of them are females. The next common formula in the normal series shows a continuous post-central sulcus without connexion with the association area of the interparietal. But in the series of the lunatics, the next figure relates to the connexion of the postcentralis superior with the interparietalis and an independent postcentralis inferior.

Karplus's law of the homologous transmission is confirmed by the brain pairs No. III, IV, VI, VII, VIII, X, XI, XIV, and nothing invalidates it in the descending parentage. There is one case showing discrepancy (XV) by collateral parentage, but as we have not the pattern of both the parents, it is not possible to check the origin of the discrepancy.

The five cases showing a posterior interruption of the superior temporal have also a less anastomosed pattern than that of their parents or of siblings, except for XIV, A, where it also appears although differently interrupted in the elder brother, who has the type *b*.

Similarity of the type occurs in five pairs of hemispheres of the first group and in seven of the second group. Regression to the common

type of the population exists for six hemispheres of children, and deviation from the common type for seven hemispheres out of eighteen.

Further examples could be demonstrated to show the value of the hereditary resemblance in the study of the convolutional pattern. Hundreds of non-relative brains are needed to show that all kinds of variations exist in the infoldings of the human cortex, but with a series of relative brains it may readily be demonstrated that one form can slowly become transformed into another, and often in the four hemispheres of one pair of relative brains the slight transition from one extreme pattern to another extreme is clearly apparent.

It is a general conclusion arrived at in this paper that the convolutional pattern has, in itself, a morphological value which justifies a specialized research and makes it necessary that it should be examined first of all apart from any other structural condition. It is only when that study has been carried out exhaustively on a greater number of brain series, that we may venture to examine the reciprocal influence of other conditions upon the fissuration of the cortex. I allude, by the way, to the investigations of hereditary similarities and dissimilarities in the extension of the architectonic fields, which have to be carried out on an equal and as extensive as possible number of brains, before any comparative conclusions will be available.

#### (VII) SUMMARY AND GENERAL CONCLUSIONS.

Fifteen pairs of adult brains related by direct parentage, and one pair of twin brains have been examined according to a morphological and a statistical method, described in a previous paper of the author, and published in the *Philosophical Transactions of the Royal Society* (1916).

Eighty-three questions dealing with the convolutional pattern were answered in the case of each pair of brains, and the results summarized and divided according to their kind of similarity and dissimilarity.

A control of comparisons with non-relative brains enabled the author to demonstrate that relative brains are more like one another than non-relative brains.

The test, carried out on a pair of negro brains, proved that racial influences do not play an important part in the results.

A series of comparisons according to the weight of the brain demon-



strate that heavy adult brains show less resemblance to the average pattern than the smaller brains; but the weight of the brain is not a dominant factor in the results, and has no individual value; its influence does not diminish the essential family resemblance.

Comparisons of mixed sexes show less similarity than do comparisons between brains of the same sex, and the tables enable one to trace the origin of this diminution in resemblance in respect of the details of the brain pattern; hence an attempt has been made to indicate the main characteristics of the typical male and the typical female brain. These indications do not permit the author to assert that a given brain belongs to a male or to a female human being; they bear only a general character.

In the case of the brains of Hebrew brothers and in those of the Negroes, there were fewer variations in the pattern than in the brains of most of the British subjects, the familial origin of which were in all probability more mixed in type.

There are proofs of differentiation between left and right hemisphere, and the comparison of the hemispheres in the same brain with each other is worthy of careful attention; the amount of variations remaining nearly the same, an increase of differentiated conditions in one part of the brain is an indication of a greater resemblance in other parts.

The same method which has been used for the whole brain comparison has been used for each of the questions to be solved regarding the convolutional pattern, and it enables one to determine which part of the cortex is of more recent development in the ontogeny (which is proved by the comparison of foetal brains), and also in the phylogeny (as suggested by comparative anatomy).

The study of relative brains is of special value in the determination of the transitions from one brain pattern to another, both as a whole and in detail. A knowledge of the normal transitions from one convolutional pattern to another may be of use in the consideration of the convolutional pattern in pathological conditions.

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The definite results arrived at in this paper are summarized in the following conclusions :—

- (1) The family resemblance of the convolutional pattern in man has an individual value. The family inheritance has a greater effect on the convolutional pattern than is exercised by the influence of brain weight or by sexual or racial influences.
- (2) The apparent similarity between left and right hemispheres in the thirty-two human brains above described, and with the method indicated, is ... 0·73  
 The apparent similarity between homologous hemispheres, and thus also between the brains, of two persons of direct relationship, is ... 0·73  
 Thus one of the hemispheres of a human brain resembles the other hemisphere as much as it resembles the homologous hemisphere of a parent, a child or a sibling.
- (3) The apparent similarity by direct relationship in man being ... 0·73  
 Incomplete similarities amount to ... 0·01,9  
 Peculiarities existing in one hemisphere out of four amount to ... 0·16,9  
 Complete dissimilarities amount to ... 0·08,2  
 1·00,0
- (4) In ninety comparisons of non-relatives, the figures are:—  
 Apparent similarity ... 0·60,38  
 Incomplete similarities... 0·02,923  
 Peculiarities ... 0·19,50  
 Complete dissimilarities ... 0·17,197  
 1·00,0
- (5) Considering that there is a constant resemblance shown for the hemispheres in man, we may believe that the apparent differences between the hemispheres of one brain consist of an amount of fixed and inherited differences and an amount of variable conditions, each of which can be revealed by the examination of brains related to the brain in question.
- (6) In relative brains, the transition from one extreme pattern to another is imperceptible; there is continuity in the evolution.

# **The Effects of High Explosives upon the Central Nervous System.**

BEING  
THE LETTSOMIAN LECTURES  
DELIVERED BEFORE  
THE MEDICAL SOCIETY OF LONDON  
ON  
*February 7th and 21st and March 6th, 1916,*

BY  
FRED. W. MOTT, M.D. LOND., F.R.C.P. LOND., HON. LL.D. EDIN., F.R.S.,  
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1916.



## THE LETTSOMIAN LECTURES.

### THE EFFECTS OF HIGH EXPLOSIVES UPON THE CENTRAL NERVOUS SYSTEM.

By FRED. W. MOTT, M.D. Lond., F.R.C.P. Lond., Hon. LL.D.  
Edin., F.R.S.

#### LECTURE I.

MR. PRESIDENT AND GENTLEMEN,—Permit me to thank you for the great honour the Medical Society of London has done me in asking me to give the Lettsomian Lectures this year. The Society has been fortunate in having had addresses and discussions on most of the medical and surgical problems concerning the war, with the exception of the effects of high explosives upon the central nervous system in the production of functional neuroses and psychoses. As I have had the opportunity of studying these effects, I ventured to change the subject which I at first contemplated.

The employment of high explosives combined with trench warfare has produced a new epoch in military medical science. This war was recently described at a Labour Congress as a barbarous, unromantic, machine war. Yet in no war of the past have individual courage and self-sacrifice shone with greater lustre; for the contemptible little army in the retreat from Mons fought against overwhelming odds and covered itself with glory. Again, in the terribly anxious times when the enemy tried to break through to Calais, what could have surpassed the courage and self-sacrifice of our men in the trenches on the Yser, or the gallant stand of the Canadians when the Germans sprang the gas upon us? Lastly, the landing of the Anzacs is one of the finest and most romantic deeds in the history of war.

High explosives contained in huge shells have played a prominent part in this war, and, apart from the effects produced by direct

material injury to the central nervous system, there is the moral effect of the continued anxious tension of what may happen, which, combined with the terror caused by the horrible sights of death and destruction around, tends to exhaust and eventually even shatter the strongest nervous system. To live in trenches or underground for days or weeks, exposed continually to wet, cold, and often, owing to the shelling of the communication trenches, to hunger, combined with fearful tension and apprehension, may so lower the vital resistance of the strongest nervous system that a shell bursting near, and without causing any visible injury, is sufficient to lead to a sudden loss of consciousness. So that, in considering the effects of high explosives, it is absolutely necessary to take into account the state of the nervous system of the individual at the time of the "shock" caused by the explosive. A neuro-potentially sound soldier in this trench warfare may from the stress of prolonged active service acquire a neurasthenic condition, and it stands to reason that a soldier who has become neurasthenic from a head injury or from the acquirement of a disease prior to his enlistment will not stand the strain as well as a neuro-potentially sound man. Again, if in a soldier there is an inborn timorous or neurotic disposition or an inborn germinal or acquired neuropathic or psychopathic taint causing a *locus minoris resistentiæ* in the central nervous system, it necessarily follows that he will be less able to withstand the terrifying effects of shell fire and the stress of trench warfare. Thus, whether a tendency to a neurasthenic condition has been acquired or is more or less inborn, an emotional experience such as fright is more liable to develop the symptoms of a functional neurosis or psychosis.

#### THE EFFECTS OF HIGH EXPLOSIVES UPON THE CENTRAL NERVOUS SYSTEM.

The effects of high explosives upon the central nervous system fall into three groups:—

1. Immediately fatal either from pieces of shell, stones, rocks, or portions of buildings striking the individual, causing instant death, or the person may be buried from the explosion of a mine. Again, instant death must have occurred in groups of men from the effects of shell fire and yet no visible injury has been found to account for it. This matter I shall discuss more fully later.

2. In Group 2 we can place those cases in which the detonation of high explosives has caused wounds and injuries of the body, including the central nervous system, which have not been immediately fatal. The number of these cases which do not exhibit any of the functional disorders and disturbances characteristic of what is termed "shell shock" without visible injury, although such individuals have received most serious and fatal wounds from exploding shells, leads one to consider that in a large proportion of cases of shell shock without visible injury there are other factors at work in the production of the nervous symptoms besides the actual aerial forces generated by the explosive.

3. The third group includes injuries of the central nervous system without visible injury, and to this group I shall give especial attention, as it is the one of which I have had most experience. I include the functional neuroses and psychoses because, although there may be no discoverable lesion in a "psychic trauma," yet so complex is the structure of the human central nervous system, and so subtle the chemical and physical changes underlying its functions, that because our gross methods of investigating dead material do not enable us to say that the living matter is altered, yet, admitting that every effect owns a cause, a refractory phase in systems or communities of functionally correlated neurons must imply a physical or chemical change and a break in the links of the chain of neurons which subserve a particular function. As we know, one of the peculiarities of the functional neuroses is not only the sudden manner in which an emotional shock may engender a loss of function, but likewise the sudden manner in which it may be unexpectedly restored by a sudden stimulus of the most varied kind, provided there is an element of surprise. That is, attention is for a moment taken off its guard. I am referring especially to mutism. The causes of shock to the nervous system by high explosives may be considered under the headings of physical trauma—concussion or "commotio cerebri" by direct aerial compression or by the force of the aerial compression blowing the person into the air or against the side of the trench or dug-out; or by blowing down the parapet or roof on to him, causing concussion, or a sandbag hitting him on the head or spine might easily cause concussion without producing any visible injury. Again, he might be buried and partly asphyxiated

or suffer from deoxygenation of his blood by CO poisoning, for, as I shall prove later, these high explosives generate considerable quantities of CO, which is inodorous and would not be recognised. A man lying unconscious or even conscious and partly buried and unable to move would be very liable to be poisoned by CO and not know anything about it; nor would the rescuers, as the poisonous effects of the gas depend upon the amount in the atmosphere and the length of time to which the individual is exposed to it.

#### A BRIEF SURVEY OF THE DYNAMIC CONDITIONS OF THE CENTRAL NERVOUS SYSTEM, ESPECIALLY IN RELATION TO THE CEREBRO-SPINAL FLUID AND SHOCK.

The whole central nervous system is contained in a closed space, the walls of which are formed by the cranium and spinal column, inside of which is the stout dura mater. Within this closed space is the cerebro-spinal fluid, which fills up all the space not occupied by blood-vessels or tissues. The cerebro-spinal fluid thus serves to equalise the pressure throughout the whole cranio-spinal cavity; moreover, at the base of the brain, where the vital centres of the medulla are situated it acts as a water cushion, protecting them from the shock of commotion and concussion. The cerebro-spinal fluid also serves as a self-adjusting mechanism by maintaining a uniform equalisation of the blood supply to the nerve elements during the rhythmical variations of respiration and circulation. Now this fluid is incompressible, and under ordinary conditions of pressure from without it serves as a perfect protective mechanism, but when large quantities of these high explosives are detonated an enormous aerial compression is instantly generated, and it is quite possible that this may be transmitted to the fluid about the base of the brain and cause shock to the vital centres of the floor of the fourth ventricle, causing instantaneous arrest of the functions of the cardiac and respiratory centres. Lord Sydenham, one of the highest authorities on the dynamics of explosives, concludes that the forces generated are sufficient to cause instantaneous death, and he has informed me that in the American Medico-Military Report it is stated that "an aneroid showed that the explosion of one of these shells caused a sudden atmospheric depression of about 350 mm. of the mercury tube, corresponding to a dynamic pressure



of about 10 tons to the square yard." One effect of this is to liberate air suspended in the blood and transform it into bubbles of gas which are driven into the capillary vessels and cause instant death. The writer, Surgeon Fauntleroy, is not satisfied with the explanation, which "does not take into account the primary air compression by which men are sometimes hurled into the air." He (says Lord Sydenham) considers, as I do, that the blow on the body, especially over the heart and abdomen, may cause instant death. I have had officers under my care who have been blown in the air considerable distances. One Royal Army Medical Corps officer told me he was blown 30 feet; another told me that he was blown a considerable distance in a communication trench and lost consciousness for some time; another told me that the effect was like a violent push of irresistible force with a down cushion. But I shall have occasion later to refer to this explanation of sudden death when considering the various theories regarding the cause of death of groups of men found in postures and attitudes of the last act of life. If aërial concussion by the forces generated by high explosives can cause death without visible injury, I think more probably it would arise from sudden arrest of the medullary centres. The stem of the brain, surrounded by the cerebro-spinal fluid, is prevented from oscillating by the nerves which issue from it to pass through the holes in the skull; likewise the spinal cord, by the anterior and posterior roots and the ligamentum dentatum, is prevented from oscillating. A sudden shock of great intensity would be transmitted through this incompressible fluid, and, seeing that it not merely surrounds the central nervous system but fills up the ventricles and central canal and all the interstices of the tissues, serving as it does the function of lymph, it follows that a shock communicated to the fluid of sufficient intensity would make itself felt on all the neurons.

#### THE NEURON DOCTRINE IN RELATION TO "SHOCK" AND THE THEORY OF DIASCHISIS.\*

The central nervous system consists of innumerable anatomically distinct nervous units. Each consists of a cell with branching processes; there is one process the axon, the remaining processes

\* The full account of the theory of diaschisis is set forth by von Monakow in his recent great work, 'Die Lokalisation im Grosshirn, und der Abbau der Funktion durch kortikale Herde,' 1914.

are termed dendrons. The axon and dendrons are conductile; the chemical changes incidental to nervous action almost entirely occur in the cell. There are two types of neurons, the first type of Golgi, in which the axon leaves the grey matter to become surrounded by a myelin sheath to enter into the formation of the white matter, and the second type, in which the axon never leaves the grey matter; these are the intercalary neurons (Fig. 1). They always

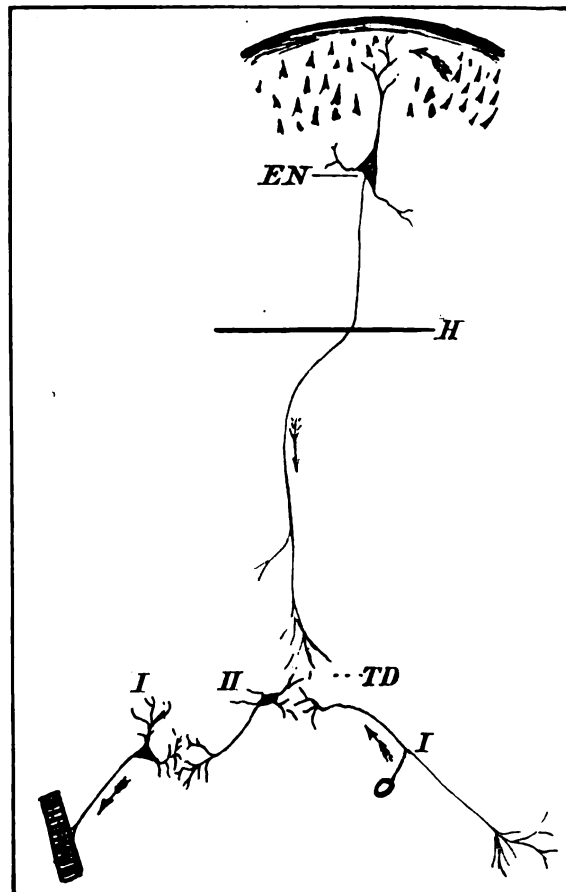


FIG. 1.—Diaschisis. EN, effector neuron of voluntary movement; H, seat of hæmorrhage in internal capsule causing shock transmitted to terminals in reflex arc of spinal cord; TD, temporary intercalary dissociation of reflex by shock.

intervene between neurons of the first type, and in the cerebral cortex they form definite layers especially well developed in the sensory projection centres, *e.g.*, of vision and hearing. I will endeavour to show how retraction of the branching processes of

these intercalary cells would shut off consciousness of the external world. These intercalary neurons possess only a small amount of cytoplasm, and are therefore unable to store oxygen. Sudden failure of the heart's action by shock, whether of physical or emotional origin, lowers the oxygen tension in the tissues, and a dissociation of the sensory projection neurons from the cortical perceptor neurons occurs.

The whole of the neurons of the central nervous system may be primarily divided into these two groups: (1) Neurons of the first type, which may again be divided into sensory or afferent projection, motor or efferent, and association neurons. (2) Neurons of the second type or intercalary. To take a few typical examples of the influence of shock affecting one part of the central nervous system being transmitted through anatomically and functionally correlated neurons to remote parts. In hæmorrhage into the internal capsule we have a sudden irruption of blood cutting through the pyramidal efferent system of fibres, resulting in a flaccid paralysis of the opposite limbs (Fig. 1); the shock effect has been transmitted to the intercalary neurons at the base of the posterior horn of the spinal cord, and for the time being it has suspended the normal reflex tonus, that is to say, dissociation of the sensory projection fibres of the reflex arc has occurred. But we know that as soon as the shock effect has passed off a spastic condition supervenes on the flaccid. The reason of this is that the normal inhibitory cortical influence has been interrupted and, association of the sensory afferent and motor efferent in the reflex arc having been restored by a return to normal function of the intercalary neurons, the reflex tonus is increased by withdrawal of the cortical inhibitory influence. Let us take another example of which I have seen several: a bullet wound of the occipital region of the skull causes complete blindness, but not deafness. After a time the patient is left with hemianopsy; the fact that the wound did not produce deafness shows that it was not general shock to the brain that led to the opposite occipital lobe being temporarily put out of function (Fig. 2). The two occipital lobes are anatomically and functionally correlated, and the injury of one lobe caused a functional dissociation by the shock effect transmitted through the association fibres of the splenium. This temporary dissociation by shock of anatomically and functionally correlated systems of neurons has been termed by Monakow diaschisis.

## THE LIVING NEURON IN RELATION TO SHOCK.

The researches of Ross Harrison on the living neuron and its growth render it possible to accept as a provisional hypothesis the theory of attraction and retraction of dendrons as an explanation of association and dissociation. The intercalary neurons may, indeed, possess amœboid movement. A study of the living neuron shows that totally erroneous ideas may arise if we are guided by the appearances presented by the neurons in sections after they have been submitted to hardening and fixing reagents. Especially

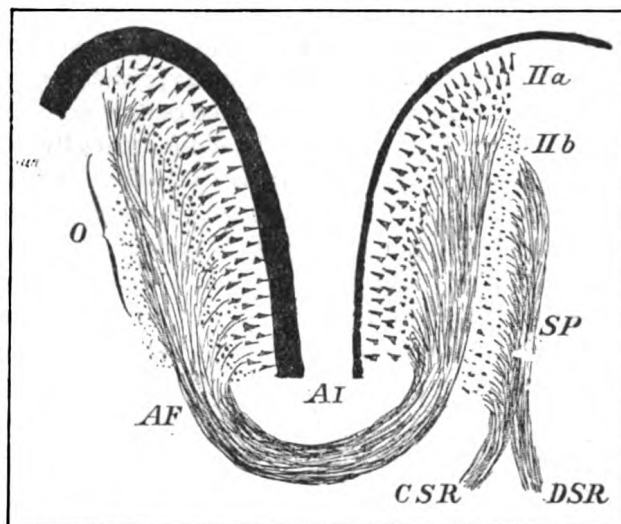


FIG. 2.—Diaschisis. O, injured occipital lobe; AF, association fibres through which shock effect is transmitted to opposite occipital lobe; AI, fibres of splenium; II, two layers of intercalary cells—(a) association, (b) sensory receptors; SP, sensory projection; CSR, crossed sensory receptor fibres; DSR, direct sensory receptor fibres.

is this so in respect to the effects of shock by concussion generated by high explosives. The remarkable observations of Colonel Gordon Holmes on gunshot injuries of the spine causing concussion of the spinal cord without penetration of the dura mater by the projectile show the importance of a consideration of the living neuron. The force of the concussion he shows produces most extraordinary changes in the axons, which become enormously swollen.

The condition of the nerve cell may be studied in sections by two methods, in one of which fibrils can be demonstrated by the silver method of Ramon y Cajal; the other by which a basophile staining substance (the Nissl granules) forms a pattern around the nucleus.

PLATE I.

[To face p. 10.]

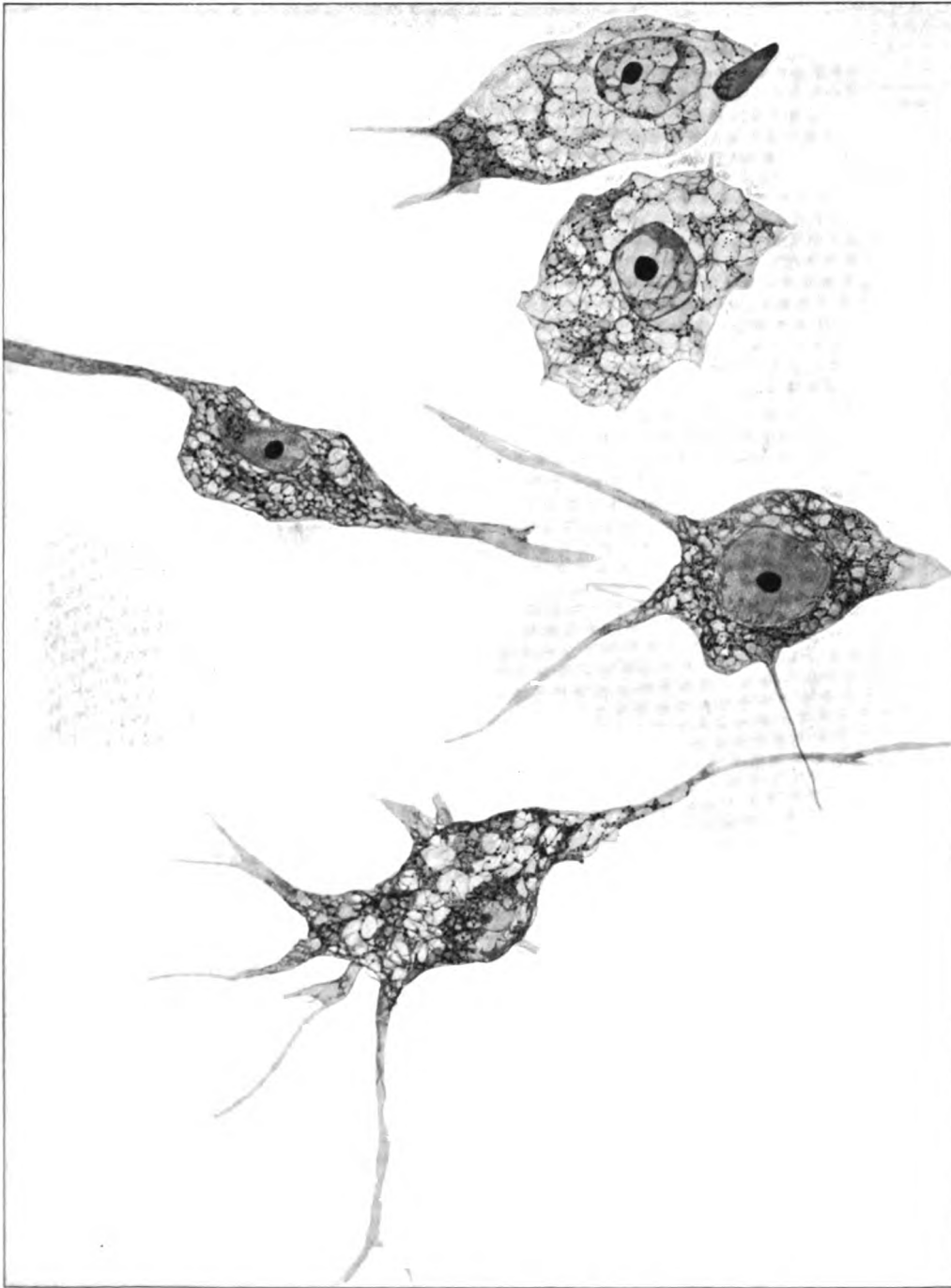


FIG. 3.—Five cells from a case of a man who lived eight hours after receiving an electric shock of 20,000 volts. A very diffuse chromatolysis with loss of basophile staining substance, thereby revealing the intracellular and intranuclear networks, is observed. Polychrome staining. Magnification 810.



2

PLATE II.



FIG. 5.—Drawing of an anterior horn cell (right hand) with processes and two posterior spinal ganglion cells as seen by dark-ground illumination while still in the living state. The cells are teased out of the tissue in warm cerebro-spinal fluid or Ringer's fluid. The microscope is placed in a warm chamber with a glass front. In this way the living cells can be observed for some time. (Obj. 4 mm., apochrom. oc. 4.)



The neuron, when damaged by injury or disease, shows various changes in the appearances of the cells whether the fibril method of staining be adopted or the Nissl granule method, *e.g.*, if the processes of the cell be cut, the living neuron is wounded, and the body of the cell after it has been killed by the process of fixation and hardening, exhibits changes; likewise, if the neuron has been damaged by a poison, changes are seen, but there is nothing specific about these changes, *e.g.*, one could not recognise any difference in the perinuclear chromatolysis of lead encephalitis, alcoholic psychosis, experimental anæmia and section of the axons of nerve cells. The Nissl granules of basophile substance, as I pointed out in the Croonian Lectures, 1900\*—"On the Degeneration of the Neuron"—do not exist in the living cell. Nevertheless, the amount of this basophile staining substance in the form of Nissl granules may be regarded as evidence of the amount of energy substance (neuro-potential) which the cells possessed during life (Fig. 3, Plate I). In the healthy cell it is continually undergoing disintegration and automatic reintegration. When the cell is damaged, metabolic equilibrium is no longer maintained, and its osmotic surface-tension is altered, and water passes into the cell causing it to swell, displacing the nucleus, and causing an appearance of chromatolysis. But this basophile staining substance which forms the Nissl granules does not exist as such in the living cells. If the living cell be examined by direct illumination, no Nissl bodies are seen in the cytoplasm, only fine dark granules like an emulsion (Fig. 4). If

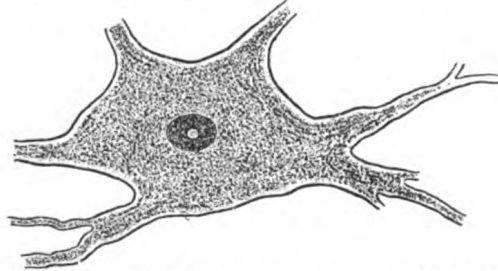


FIG. 4.—Anterior horn cell of spinal cord examined immediately after death by direct illumination. The grey matter was teased in cerebro-spinal fluid and the preparation examined on a warm stage. The cell is seen to possess no Nissl bodies, but is filled with dark granules like an emulsion. (Obj. 4 mm., oc. 4.)

living cells are examined microscopically with dark-ground illumination (Fig. 5, Plate II), they are seen to be filled with small granules or globules, each of which after escaping from the cell remains

\* 'The Lancet,' June 23rd, 1900, p. 1779.

discrete. They are refractile, and appear white and luminous; this is due to a delicate covering film of a lipoid substance which encloses a colloidal fluid, probably consisting of a solution of salts and cell globulins. When the cell dies this colloidal fluid is coagulated, and the precipitated proteid substance is massed together into little blocks—the Nissl granules; the intervening denser colloidal substance is continuous with the colloidal substance of the axon and dendrons. The film that covers each globule is stainable by vital methylene blue, and a living nerve cell stained by vital blue presents the appearance of an emulsion of minute faintly blue globules. If the living cell thus stained be kept in an atmosphere of nitrogen in a warm chamber the stored oxygen is used up and a leuco-base is formed, causing the globules to lose their colour, the cell appearing of a greenish tint. On admission of oxygen the living cell again becomes blue. It thus appears possible\* that these granules represent a large oxygen surface, like spongy platinum, within the cell. When the cells die, the lipoidal film of the globulin containing fluid is destroyed, coagulation occurs, and the Nissl granules are formed. These facts accord with the knowledge that stimulation of a piece of nerve causes practically no metabolic change or using up of oxygen, therefore the mere conduction of a stimulus along a nerve does not entail loss of neuro-potential. The chemical processes incidental to the using up of nervous energy in the neuron take place in the cell itself, and for this reason it is that the blood supply of the grey matter is six times that of the white matter. In all active neural processes oxygen is used up and carbonic acid is produced which escapes into the circumambient cerebro-spinal fluid. One stimulus differs from another that is discharged into a cell by variation in modes of motion, and it is conceivable that the granules which fill the cell are sensible to the varying modes of motion, and an oft-repeated stimulus suffices by the establishment of a biorhythm in the cell to pass through to the intercalary neuron with little expenditure of neuro-potential, whereas a new stimulus which requires a concentration of attention must be either transformed or reinforced before connexion of the terminals of Neuron I with Neuron II (see Fig. 1) can take place, and this involves a using up of neuro-potential.

\* The experiments relating to the living cell were commenced before the war, and I have not had time or opportunity to prosecute this research further; I therefore put forward this hypothesis tentatively.

Severe concussion can not only cause immediate dissociation of the cortical perceptor neurons, producing unconsciousness or a disturbance of consciousness, but for a varying period of time it can destroy the power of recollection of perceptions prior to the shock. There is a retrograde amnesia, and in very severe cases of shell shock, as I shall point out later, there may be a complete loss of memory both as regards recollection and recognition. The loss of recollection may be attributed to dissociation of the higher association systems of (pyramidal) neurons which form a sheet of cells of three layers covering the whole cortex cerebri. The loss of recognition may be attributed to a dissociation between the cortical perceptor systems of neurons, and in complete loss of consciousness of the external world there is dissociation of all the afferent projection fibres of subcortical neurons from the perceptor systems of neurons. Functional blindness and deafness, which often persist when consciousness returns, may be due to one afferent system remaining dissociated.

But why, it may be asked, do we find varying degrees of retrograde amnesia associated with loss of recollection of recent experiences, while those of earlier life may be preserved? Shock so severe, or toxic influences such as alcohol, do not cause dissociation of the neurons in which habitual actions by frequent repetition have been registered, and their revival requires a much less expenditure of neuro-potential the more they have become habitual and instinctively automatic. For the same reason the earlier experiences have been stored in memory, the more do they form the foundation upon which associative memory rests, for consciously and unconsciously these early experiences have been exerting continually their influence on the subconscious mind by association, and at the same time they have determined and been correlated with habitual and instinctive actions, requiring but little conscious effort and expenditure of neural energy.

The delicate granules filling the nerve cells have been termed "neuro-bions," as if they were independent living units, but this is theory. It is, however, conceivable that violent concussion transmitted to the cerebro-spinal fluid, which forms the circumambient medium of such a complex mechanism as the living nerve cell, could cause a violent oscillation of these neuro-bions and a loss or disturbance of their functions of variable duration according to the severity of the shock. I show here (Fig. 3, Plate I) the

appearance presented by the cells of the medulla of a man who died eight hours after receiving a shock of 20,000 volts.

#### OXYGEN AND CONSCIOUSNESS.

It is known that a continuous supply of oxygen is essential for consciousness. The bulk of the cortex is supplied by the internal carotid arteries; compression of these arteries causes loss of consciousness in about five or six seconds. Histological investigation tends to show that the intercalary neurons have no store of oxygen in their cytoplasm; they depend, therefore, upon a continuous renewal of the oxygen in the circumambient fluid; consequently, as soon as the capillary circulation ceases, they feel the effect of lack of oxygen and cease to function, causing dissociation to occur. Now a violent emotion such as fright can, by its influence on the vaso-motor centre and the heart's action, causing a fall in the blood pressure, produce an immediate lowering of oxygen tension in the fluid, and thereby suspension of function of the intercalary neurons of the cortex, followed by dissociation of the cortical perceptors and loss of consciousness. In many of the disorders of functions and loss of functions of the central nervous system resulting from shell shock, using that term in its widest sense, there occur symptoms of cortical dissociation—*e.g.*, cortical blindness, deafness, mutism, and paralysis.

The symptoms of headache, weariness, loss of power of concentration, irresolution, and mental fatigue, constituting a neurasthenic condition so frequently found as a result of shell shock, may be explained by the acquirement of the habit of drawing on the reserve of neuro-potential, and being unable through insomnia or sleep disturbed by terrifying dreams, worry, and anxiety to restore the balance and return to the normal conditions of automatic renewal of nervous energy as fast as it is used. Physical shock accompanied by horrifying circumstances, causing profound emotional shock and terror, which is contemplative fear, or fear continually revived by the imagination, has a much more intense and lasting effect on the mind than simple shock has. Thus a man under my care, who was naturally of a timorous disposition and always felt faint at the sight of blood, gave the following history. He belonged to a Highland regiment. He had only been in France a short time and was one of a company who were sent to repair the barbed wire

entanglements in front of their trench when a great shell burst amidst them. He was hurled into the air and fell into a hole, out of which he scrambled to find all his comrades lying dead and wounded around. He knew no more, and for a fortnight lay in hospital in Boulogne. When admitted under my care he displayed a picture of abject terror, muttering continually "no send back," "dead all round," moving his arms as if pointing to the terrible scene he had witnessed.

#### THE NATURE OF HIGH EXPLOSIVES AND FORMS OF PROJECTILES.

Sir Anthony Bowlby, in the Bradshaw Lecture on "Wounds in War,"\* called attention to the nature of high-explosive shells and their terrible effects. "These shells vary in weight from a few pounds to about a ton, and they consist of a thick iron case containing in a central cavity a violent explosive charge. The latter is, in the case of German shells, trinitro-toluene, and may contain as much as 200 lb. of this explosive. Such shells are burst upon percussion by a detonator, which acts by the impact of the shell upon the ground or on some other object. These shells do not contain bullets, and the injury they do is in chief part by the jagged fragments into which they are split by the explosion, and also to some extent by the impact of portions of buildings, such as stones or bricks, which are scattered with immense force by the violence of the explosion. [He might have added sandbags forming the parapet of a trench or the roof of a dug-out.] The fragments of the shells are always very rough and jagged and of every variety of size and shape. For example, the base of a 17-inch shell may weigh 150 lb., and if it struck the body of a man would completely destroy it. Other fragments may weigh a few pounds and may tear off a limb or crush it to pulp, while in the smaller shells there may be scores of fragments about the size of the end of the finger or much smaller. It must also be borne in mind that the mere explosive force of the gases of a large shell exercises great powers of destruction. The expansion of the gases is sufficient to kill, and in the only case in my experience in which an autopsy has been made the brain was the seat of very numerous petechial hæmorrhages." This brain, by the kindness of Professor Arthur Keith, has come into my possession, and the result of the microscopic

\* 'The Lancet,' December 25th, 1915, p. 1385.

examination I shall deal with fully in my next lecture. Suffice it to say that the appearance it presented led me to suspect CO poisoning. But high explosives are used also in mines, and in various other forms of projectiles, such as aërial torpedoes, whizz bangs, and grenades. It is, however, the big shells and mines which are so deadly in producing fatal or serious effects on the central nervous system without visible external signs of injury.

The following cases show the great force generated by high explosives:—

A lieutenant under my care told me that he was in a communication trench when an aërial torpedo exploded close to him. He felt a great pressure against him; it was soft but sufficiently powerful to knock him down unconscious. He did not know how long he was unconscious, but thinks it must have been an hour. When he recovered consciousness he got up and was helped away. His head felt as if it would burst, and ever since he has had a whizzing in the left ear and dizziness. Dreams of bombs and aërial torpedoes bursting. There was no parapet to blow down on him.

A captain in the R.A.M.C. told me that a large shell burst at his back and he was blown 15 yards by the aërial disturbance.

An R.A.M.C. officer at the battle of Ypres had a shell explode near him. He was not hit, but lay unconscious for six hours. He recollects the shock of the shell as he went out of the dressing-room. For some days he suffered with severe headache and soreness of back of head and down the spine; the lower extremities felt heavy, but there was no loss of feeling. He had retention of urine for a day only, and around the body there was a pain like an appendix pain. He rapidly recovered.

#### THEORIES REGARDING CAUSATION OF INSTANTANEOUS DEATH OF GROUPS OF MEN.

At various times, from the earliest periods onwards in the war, journalists have given vivid descriptions of shell fire causing instantaneous death of groups of men. Ashmead Bartlett, in his graphic description of fighting in the Dardanelles, relates what he found in "A Valley of Death." "In one corner seven Turks, with their rifles across their knees, are sitting together. One man has his arm around the neck of his friend and a smile on his face, as if

they had been cracking a joke when death overwhelmed them. All now have the appearance of being merely asleep; for of the seven I only see one who shows any outward injury." How can we explain death without apparent bodily injury, yet so instantaneous as to fix then in the life-like positions and attitudes thus realistically described? Did rigor mortis come on immediately, and what was the cause? Officers and soldiers have told me that they have felt ill and vomited with the gases generated by these high-explosive shells. A Canadian officer told me that in the first gas attack made by the Germans he felt ill and vomited with the gases generated by the high-explosive shells. The smell has, like that of bananas, a faint sickly odour that made him feel ill and vomit, and quite different to the "gas." In considering the causation of fatal shell shock without visible sign of injury it is necessary, therefore, to take into account chemical changes in the atmosphere together with the physical forces generated by the explosive. The effect of the emanation of a poisonous gas was the explanation at first given for instantaneous death without physical sign of injury; it was widely bruited about that turpinité, a French high explosive, produced a deadly gas which would be quite capable of producing sudden death without visible signs of injury; but the question even then arises, Why should the body remain in a life-like position? Many authorities regard it as much more likely to be due to the effects of concussion on the nervous system. Cases that have recovered after severe concussion without visible sign of injury may, nevertheless, have received physical concussion by sandbags blown down from the parapet into the trench, or, if the shell burst in a dug-out, the earth may be driven down with great force, burying the inmates. A case, however, came under my care, in which there was no history of this happening, from No. 6 C.C.S., 24-25.9.15, as follows:—

"This man was blown up by a shell and was found in the dug-out with his two comrades, both of whom were dead. While here he has been quite insensible to all questions. He has been in a cataleptic state, with at times convulsive seizures. His light reflexes are present."

He was removed to No. 30 C.C.S.I., and further notes state: "Reflexes very active. Urine drawn off 1 pint; when tested showed marked albumin. Both pupils widely dilated. Speaks

incoherently occasionally. There is *no outward evidence of any injury* or symptoms of pain anywhere." Five days later he was admitted to the 4th London General Hospital. He complained of a strange feeling in his head, and sweated profusely. He was terrified when the corporal in charge shook him to try and stop his shouting and mumbling. He complained of severe headache of the vertex, shook a good deal, and said everything in front of him looked blurred. He could hear and comprehend what was said to him, and spoke in reply to questions ; subsequently he made a complete recovery.

The fact that there was albumin in the urine when it was drawn off and no visible sign of injury suggests that inhalation of noxious gases in a closed space was an important contributory cause of the death of his two comrades and of the severe temporary symptoms which he manifested. But, it might be argued, if poisonous gases generated by the explosion caused death, it is only by inhalation while the man is lying on the ground unconscious or partially buried, and this would not account for the sudden death where groups of men are found fixed in the last act of life. M. Arnoux, a French civil engineer, has studied this question, and has suggested another theory which is extremely interesting. A pocket aneroid barometer carried by an officer had been exposed to an explosion of the kind referred to, and was put out of working order by the force of the concussion. M. Arnoux had the aneroid repaired ; he then placed it under the reservoir of an air pump and exhaust until he had produced the same effect on the aneroid as was observed before it was repaired. He calculated from observations and experiments that the dynamic pressure exerted by the surrounding air on bodies within a few yards of the exploding shells had amounted to over 10,000 kilos. per square metre. Men standing close to the exploding shell would be blown into the air or dashed against the ground with great violence, but in the case of men leaning against the side of a trench wall only the static depression could affect them. What, M. Arnoux asks, would be the effect on the human organism of so powerful and so sudden a decompression ? It would, he answers, be similar to that which causes the deaths of aëronauts who make too rapid an ascent or of workers in compressed air caissons who leave their caissons too quickly and without taking proper precautions for their slow



decompression, namely, the sudden escape from the blood of bubbles of air and  $\text{CO}_2$ , which would produce capillary embolism throughout the body and cause sudden death. M. Arnoux's theory is, then, that the sudden increase of atmospheric pressure produced by the explosion is capable of producing an immediate increased absorption of air and  $\text{CO}_2$  by the blood, followed by a sudden liberation on return to normal conditions.

Surgeon-General Stevenson,\* commenting upon the theory of M. Arnoux, asks: "Is it possible that a sudden increase of atmospheric pressure, lasting only a fraction of a second, no matter how great it might be, could so charge the blood with gases that their discharge into the blood stream when the pressure ceases would cause death in the same manner as a too rapid return to ordinary atmospheric pressure in caisson workers?" He advocates the theory of concussion of the central nervous system as the most satisfactory explanation; the water jacket of the cerebro-spinal fluid serves as a protection to the vital centres of the medulla under all ordinary conditions of *commotio cerebri*. But in these cases (as M. Arnoux's experiments prove) we are dealing with extraordinary conditions of atmospheric pressure: a pressure force which we believe is sufficient to cause a temporary loss of consciousness, temporary blindness, deafness, paralysis, and loss of speech without any visible signs of injury. If the functions of the higher centres are for a time instantaneously suspended by the shock, it is conceivable that in the severest cases the functions of the vital centres of the medulla may be instantaneously suspended by its concussion; moreover, the hæmorrhages in the corpus callosum and the basal ganglia found in the brain referred to might, accepting this view, be explained by the fact that the ventricles are filled with incompressible fluid to which the violent shock is transmitted.

The cases that have recovered after severe shell shock very rarely show signs or symptoms of organic disease.

But suppose the air is charged with carbon monoxide and oxides of nitrogen, would it not be possible for the man to inspire enough of these gases to cause instant death? I wrote to Professor Leonard Hill on this subject, and I received the following very interesting reply:—

\* "Note on the Cause of Death due to High-Explosive Shells in Unwounded Men," *Brit. Med. Journ.*, September 18th, 1915, p. 450.

"The explosion of a big shell in a trench, dug-out, cellar, or other confined space must, I think, instantly deoxygenate the air and produce a high concentration of carbon monoxide and oxides of nitrogen. The inspiration of a man at the moment of explosion may introduce enough of these gases to cause death from want of oxygen. If he is fatigued his muscles will be in the condition to go into rigor on the sudden deprivation of oxygen. It would be of great interest to get samples of blood from men killed by shell shock. I do not see how the alteration of air pressure can do more than act on the gas in the guts and on the lung. The sudden compression of the lungs by several atmospheres must be considered. The pressure will probably act quicker through the wall of the thorax than down the trachea. I do not see how a sudden squeeze of the thorax is going to do any harm, and the pressure will be equally distributed through the fluids of the body in all directions, and it is not enough to break the thoracic wall by the sudden compression of the gas in the lungs. A copper ball with a glass tube sealed up full of air sunk in the deep sea is broken in when the glass tube bursts in spite of a free opening into the copper ball. I imagine the thoracic wall might be broken in by a sufficient sudden pressure. The elasticity of the atmosphere is such that this does not occur. I once carried out some experiments on the effect of exploding heavy charges of guncotton on pigs. A few feet of air was enough to save the pigs from damage. When the guncotton exploded near the ground the soil, stones, etc., were converted into missiles, and these wounded the pigs. The lungs of these pigs showed some patches of emphysema, as if the sudden wave of air pressure had driven air from one part of the lung into other parts.

"I should say the men either die, as you suggest, from the gases—deoxygenation of blood—or else from concussion."

Also through Lord Sydenham I have heard from the Secretary of the Trench Warfare Department that it is possible that the partial detonation of a large shell containing, say, 50 to 100 lbs. of T.N.T. would produce enough carbon monoxide in the immediate vicinity to give rise to the characteristic poisonous effects of this product.

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## LECTURE II.

Mr. PRESIDENT AND GENTLEMEN,—Many of the symptoms of CO poisoning are similar to those which I have observed in shell shock with burial. It must not be supposed that in poisoning by illuminating gas or CO poisoning recovery is always complete, nor that the mental symptoms are always only of a transitory nature. It often takes months for the effects of the poisonous action of CO on the heart and nervous tissue to wear off, and in certain cases the damage is permanent. Some years ago I was called to see an officer who had been gassed in a submarine; he was mute, but while I was there talking to his mother he suddenly spoke, saying, "That is my mother's voice"; his mind was gravely affected; his powers of recollection and recognition were almost lost. He was a good mathematician, but after the accident he could not do the simplest calculation—in fact, there was a profound dementia. Even two years later his mind was seriously affected, although he had a return of power of recollecting his later experiences.

The Crarae disaster in 1885 is of interest. A monster blast of gunpowder in a quarry attracted a number of persons from Glasgow. Twenty minutes after the explosion 100 onlookers collected in the quarry; 40 were rendered immediately unconscious, others fell down in a state of giddiness. Of the 40 seriously affected, 6 died. Some of those who recovered developed convulsions on regaining consciousness; in others there was delirium, after which the patient became drowsy and slept. No secondary complications occurred, but in all there was great prostration, and a long period elapsed before they regained their strength. Haldane has found that the first decided symptoms occur when the blood is saturated with about 30 per cent. of CO; with every degree of saturation up to 50 per cent. the dangerous symptoms increase, until loss of power and staggering prevent the individual escaping. Even after prolonged exposure to 0·1 per cent. of CO, recovery is possible. With 0·2 per cent. loss of consciousness and loss of power occur, and in course of time death ensues. Exposure to 0·3 per cent. proves rapidly fatal. Inasmuch as this gas is inodorous, soldiers would be quite unaware of its presence, and, lying unconscious in a dug-out or buried by sandbags in a trench which was being heavily shelled, they would stand a good chance of being poisoned by the gas even though the percentage of CO in the air is very small, for this

gas is cumulative in its deoxygenating effects on the blood by its continuously displacing the oxygen in its combination with the hæmoglobin. A sapper told me that the enemy exploded a mine, and he and another out of a party of seven were the only soldiers who were taken out alive; none of the party were visibly injured, but he was unconscious for an hour or more. They were affected by the explosion and poisoned by the gas. He had been a miner, and said the gas came through into the sap. While in the field hospital, "and after he had regained consciousness, he saw one of the bodies; it looked as if it were alive; the cheeks and lips were pink." He vomited, suffered with breathlessness and palpitation, and for some time with a splitting headache. He now is suffering from weakness and pronounced tremor of the lower extremities. His symptoms entirely agree with many of the cases of shell shock. An officer who, prior to heavy shelling of the trench in which he was, had been in good health, was invalided home on account of headache, breathlessness on exertion, and palpitation. There was no organic lesion of the heart, and I could best account for the symptoms he complained of by CO poisoning. Another officer in the Engineers, a mine expert and of long service, told me that no doubt men who were buried in trenches or dug-outs would be liable to get CO poisoning before they were evacuated and rescued. The French military authorities have long been aware of the dangers of mine explosions; they speak of "l'enivrement de poudre."

#### SYMPTOMS OF CO POISONING.

The subject of CO poisoning, including the symptoms, is admirably discussed by Glaister and Logan in their standard text-book, "Gas Poisoning in Mining and Other Industries." These authors point out that the commonest of all symptoms are headache, which may take the form of distension of the head without pain, ringing in the ears, interference with vision, which may become indistinct and blurred, hallucinations of sight and even blindness, giddiness, especially on exertion, powerlessness, yawning and weariness, often vomiting, shivering and feeling of cold, palpitation of the heart, and a feeling of oppression in the chest. The action of CO is most marked upon the central nervous system. When men affected regain consciousness they appear dazed and stupid, and generally have no recollection of what happened. There is mental confusion,

and they seem to have no power of concentration of thought, and they are unable to answer questions properly. Indeed, some of them look as if they were recovering from a drinking bout. The slightest anxiety or excitement will bring on a return of the symptoms complained of, such as tightness or oppression in the chest, palpitation and various pains and feelings of distress about the head, while beads of perspiration may appear on the forehead. Excitable and over-anxious members of rescue parties are the most susceptible to the effects of CO. Persons with a nervous predisposition, therefore, as in the case of shell shock, are more susceptible to the effect on the nervous system. Emotional shock from terror may, as in the case of exposure to high explosives, play an important part in the production of these symptoms of functional neurosis. Leigh reports an accident where two men were gassed in a pit: one died, the *post-mortem* examination revealed cerebral hæmorrhage; the other, four months later, was unfit for work. He suffered much mentally, was depressed, had lost his memory, and ultimately fell into a condition of melancholia, was readily fatigued, and there was inability to concentrate his attention.

A very important derangement of the mind in CO poisoning is loss of memory. Knapp has recently recorded a case where, besides a very intense retrograde amnesia, there was also loss of recognition. This loss of recollection is not only of what happened at the time of the accident and for a certain time subsequently, but it is also retrograde—in fact, a whole period of time may be erased from the mind. Bloch has recorded a case where loss of memory without any other disorder was a prominent symptom. Glaister and Logan also call attention to disturbances of speech. In some survivors speech is affected. The power of speech may be lost for some time or it may come back after many days. In some there is difficulty in uttering the words, and, as the patient's mind is generally confused, and his reaction slow, a curious impression is given to the observer of great effort being required to speak by the patient. The patient often repeats himself, iterating and reiterating words and phrases. This affection of speech generally only lasts for a few days, but in rarer cases it may be months and years before speech returns to normal. When this happens there are generally other mental symptoms. Tremors frequently occur. These symptoms so accord with those functional disorders of the central nervous system which have so frequently been found to

occur in shell shock with burial that one naturally thinks it possible that while lying unconscious at the bottom of a trench or dug-out sufficient CO is inspired to cause these severe effects on the mind which some of these cases exhibit. In some cases there are marked tremors, and when intentional and accompanied by other signs a condition of disseminated sclerosis may be considered (Plates III-IV, Figs. 6-8). A case with multiple punctate hæmorrhages that was not fatal might easily occasion islets of sclerosis, and this may be the explanation of a case narrated by Dr. Wilfred Harris.

HISTOLOGICAL CHANGES IN THE BRAIN IN CO POISONING,  
SHELL SHOCK, AND SPINAL CONCUSSION.

I will now describe briefly the changes which I have found occurring in the brain in poisoning by CO, for they seem to be identical with those found in the case of the brain of a man admitted unconscious with a history of having been buried by a shell blowing in the parapet. The history does not relate how soon after burial he was excavated.

Two of the cases which I have investigated came from carbonyl of nickel works, and, as you will observe, there are multiple punctate hæmorrhages throughout the white matter, especially observable in the corpus callosum, the internal capsule, cerebral peduncles, and centrum ovale (Plates III-IV, Figs. 6-8). CO is used in the manufacture of carbonyl of nickel, and I have no doubt that it was inhalation of this gas which caused the deaths. I had also the opportunity of examining the brain of a woman who killed her two children and committed suicide by taking off the gas burner and allowing the gas to escape into the room where she was with her children. The children were found dead in the room. She died four days after admission to Charing Cross Hospital. Her blood was examined spectroscopically and by Haldane's method (Plates IV-V, Figs. 9 and 11). I found in this case the same multiple punctate hæmorrhages throughout the same situations, especially in the white matter of the brain. Examination of the medulla by Nissl method showed exhaustion of the Nissl substance in the cells (Plate V, Fig. 11). A full account is given by Logan and Glaister, with illustrations taken from the original communication.\* I want you to take note of these photographs and

\* Mott, "Carbon Monoxide and Nickel Carbonyl Poisoning," 'Archives of Neurology,' vol. iii, 1907, p. 247 *et seq.*

[To face p. 24.]

PLATE III.

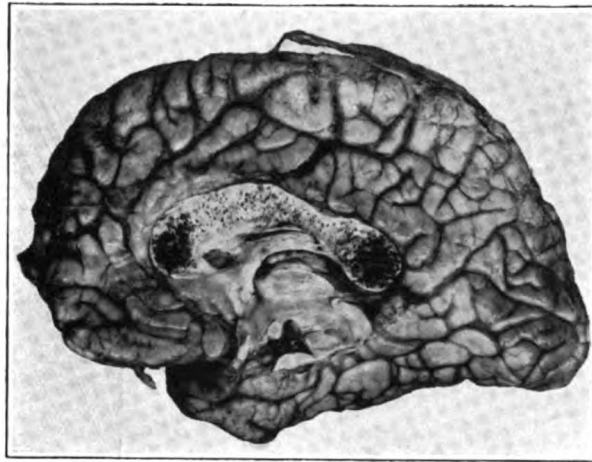


FIG. 6.—The right hemisphere of a worker at the nickel carbonyl manufactory, probably CO poisoning. Note the punctiform hæmorrhages in the corpus callosum which have coalesced into hæmorrhagic masses at each extremity.



FIG. 7.—Vertical sections through the hemispheres, showing coalescence of the punctiform hæmorrhages in the corpus callosum and internal capsule and throughout the whole of the white matter punctiform hæmorrhages.

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PLATE IV.

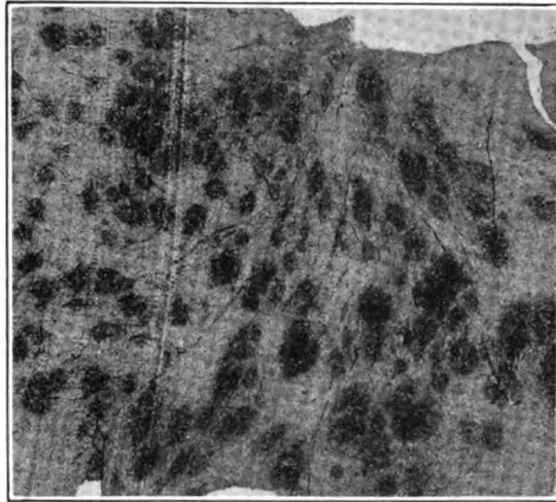


FIG. 8.—Photomicrograph of a section of the corpus callosum, showing the hæmorrhages. (Magnification 10 diameters.)

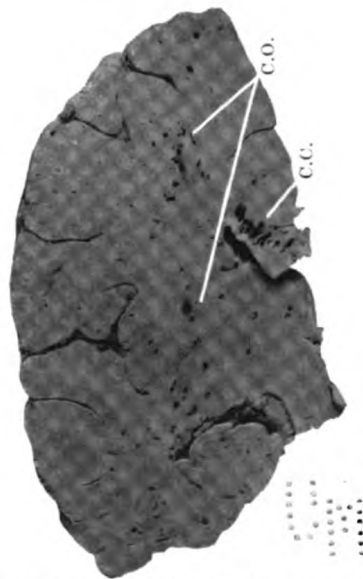


FIG. 9.—Vertical section of a cerebral hemisphere of a woman who committed suicide by inhalation of illuminating gas. Death in four days. Spectrum of blood showed CO poisoning. There are punctiform hæmorrhages throughout the white matter which have coalesced in some situations, notably the corpus callosum (C.C.) and centrum ovale (C.O.).



PLATE V.

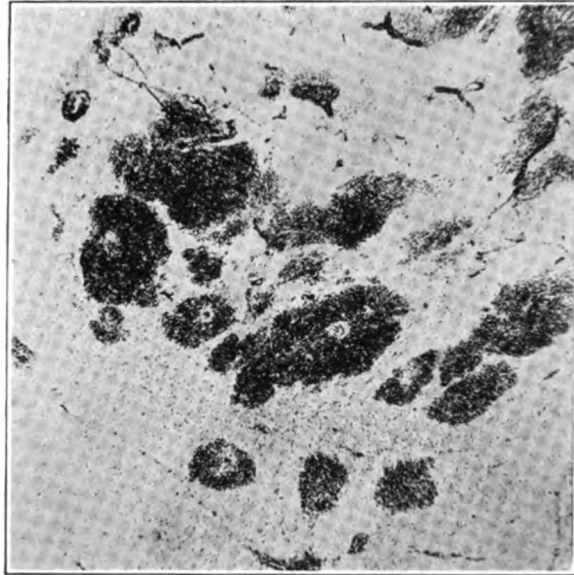


FIG. 10.—Photomicrograph of section of corpus callosum from case of shell shock, showing the capillary punctate hæmorrhages. In several cases a small white area is seen of brain tissues in the centre of which is a small artery or vein. (Magnification 20 diameters.)



FIG. 11.—Section of medulla oblongata from case of gas poisoning, stained by Nissl method, showing the swollen cells of the nucleus ambiguus. Observe the enlarged, clear, eccentric nucleus; the surrounding cytoplasm shows an absence of Nissl granules. In not a single cell is the nucleus seen in the centre as it should be. (Magnification 450.)



PLATE VI.

[To face p. 24.]



FIG. 12.—Section through the whole brain, Case 1, shell shock without visible injury, 1 inch external to the mesial surface. Punctiform hæmorrhages are seen in the white matter which have coalesced in the corpus callosum, corona radiata, and in the white matter of the hemisphere generally.

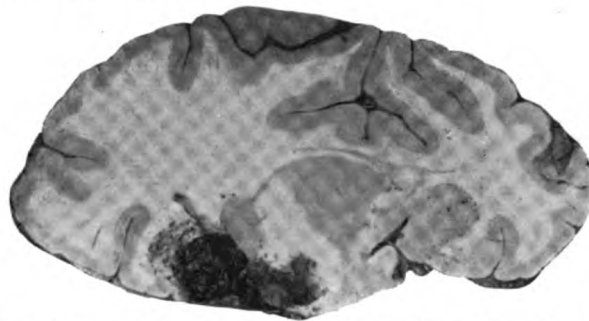


FIG. 13.—Vertical section through the left hemisphere in the frontal region, showing coalescence of hæmorrhages in the corpus callosum, internal capsule, and lenticular nucleus.

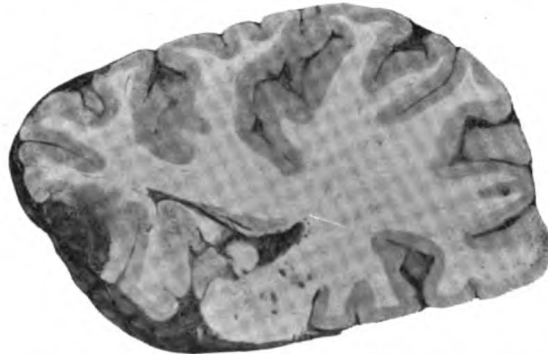


FIG. 14.—Vertical section through hemisphere, Case 1, showing a wedge-shaped area of coalesced hæmorrhages upon the under surface of the anterior part of the occipital lobe. This is the only region where the hæmorrhages had coalesced so as to form in the grey matter an area visible to the naked eye, but throughout the cortex, as in the case of CO poisoning, there are capillary hæmorrhages; at this situation the hæmorrhage has ruptured the grey matter and produced a subpial extravasation. The microscopic appearances of the hæmorrhages in no way differ from those seen in Figs. 8 and 10.



PLATE VII.



FIG. 15.—Photomicrograph of a Betz cell, showing swelling of the cell; disappearance of the Nissl bodies. The nucleus is clear, large, and eccentric; in the immediate neighbourhood are cells in which this change has not occurred. It is probable that hæmorrhage has ruptured the axon of this particular cell. (Magnification 800.)

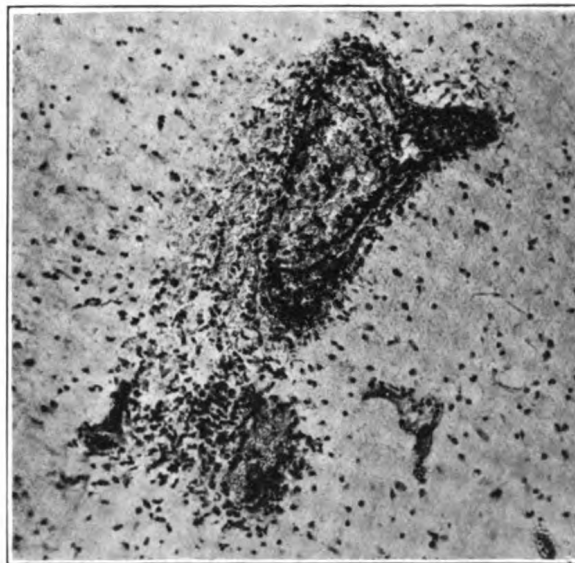


FIG. 16.—Photomicrograph of section of corpus callosum, showing inflammatory change around a small vein, a branch of which has ruptured. The deeply stained cells that are seen in the perivascular sheath are leucocytes. (Magnification 200.)





PLATE VIII.

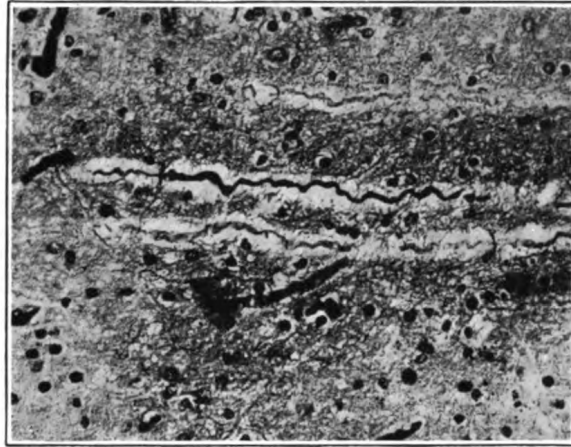


FIG. 17.—Myelinated projection fibres in the motor cortex. Three twisted axis-cylinders are seen; they are not swollen. (Magnification 300.)

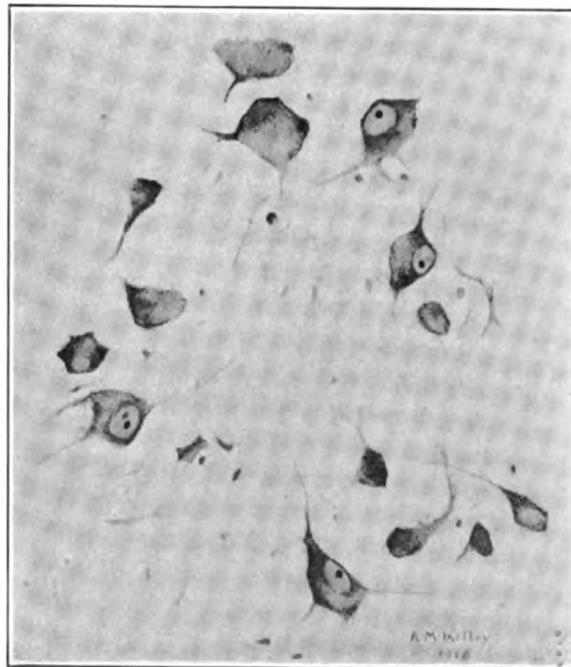


FIG. 18.—Section of medulla oblongata from case of shell shock with burial, stained by Nissl method, showing the swollen cells of the nucleus ambiguus. Observe the enlarged, clear, eccentric nucleus; the surrounding cytoplasm shows an absence of Nissl granules. In not a single cell is the nucleus seen in the centre as it should be. (Magnification 450.)

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photomicrographs, for I think you will agree with me that they closely correspond to those observed in the brain (Plate VI, Fig. 12) which I am about to describe, and of which I will show photographs and photomicrographs.

*CASE 1. Fatal Case of Shell Shock with Burial.*—Specimen received from Captain W. E. M. Armstrong, R.A.M.C., No. 7 Mobile Laboratory, B.E.F. Sent on from No. 1 Mobile Laboratory. No. 8 on Captain Armstrong's list. Brain of man (Plate VI, Figs. 12–14) admitted unconscious with history of having been buried by shell blowing in parapet. Remained stertorous for two days and died.

*Post mortem.*—There is no wound of any kind on his body or head, and no visceral lesion. His ankle on one side was badly "sprained," but there were no fractures. The skull was unfractured, and no fracture of the base could be found. Brain shows multiple capillary hæmorrhage and (some slight) subpial extravasation. No other particulars.

*Histological Examination of the Brain.*—Throughout the white matter of the centrum ovale, and especially in the corpus callosum internal capsule (Plate VI, Figs. 12–14) and cerebral peduncles, are multiple punctate hæmorrhages. They also occur in the sub-cortical white matter and in the basal ganglia. In many places these hæmorrhages have coalesced into large areas and in the parieto-occipital region there is a diffuse purple staining of the white matter around the hæmorrhagic area. Microscopic examination shows isolated capillary hæmorrhages in the grey matter; in the medulla there are only congested vessels, but no hæmorrhages. This appearance to the naked eye corresponds to that which I have described in CO poisoning. Sections of the brain were cut after hardening and embedding in celloidin and stained with hæmatoxylin eosin, van Gieson, and by Nissl method. The same microscopic appearances were observed as those seen in coal gas (CO) poisoning, only the hæmorrhages were more extensive. As in the case of coal gas poisoning where the patient lived four days, instead of 48 hours, as in this case, the cells of the medulla (Plate VIII, Fig. 18) showed a marked chromatolysis with swollen clear eccentric nucleus, similar to the change observed in experimental anæmia of animals. It is most marked in the cells of the vagus nucleus, but more or less general throughout. In the cortex many of the Betz cells show a very marked chromatolysis,

swelling of the cell and eccentric nucleus, while others in the immediate neighbourhood may possess a fairly normal amount of basophile Nissl granules. But all stages may be met with. These photomicrographs show the above-mentioned changes which correspond with those due to deoxygenation of the blood by CO poisoning or by experimental anæmia by ligation of all four arteries. As I can find the most extensive hæmorrhages, but no evidence of sudden death and swelling up of the axons as in the case of spinal concussion, I have come to the conclusion that it is possible, if not probable, this man was rendered unconscious by shell shock, and that while buried he was poisoned with gas. I am of opinion that the evidence is strong enough to warrant clinical attention being given to this matter, and the blood of persons who are suffering from so-called shell shock resulting in unconsciousness, especially where there has been burial, should be tested for CO poisoning.

The following notes were received through Major C. S. Myers of a case of spinal concussion without visible external injury, in which excavation was effected within five minutes of burial :—

CASE 2. *Spinal concussion from burial ; no gross injury, no fracture and no dislocation of vertebrae. Macroscopic hæmorrhage in cervical cord ; characteristic microscopic changes. Paralysis of both arms, legs, and intercostals, anæsthesia ; consciousness retained until death.* — Lance-Corporal A——, admitted to No. 17 Casualty Clearing Station on September 11th, 1915, suffering from paralysis. Captain W. J. Adie, R.A.M.C. (S.R.), writes :—On the morning of the 10th instant, during a heavy bombardment of one of the trenches, this man was buried in his dug-out under timber, sandbags, and earth. He was excavated within five minutes, and it was noted that he had lost the use of his arms and legs. He was conscious and rational. He did not complain of pain. I was not called to see the man as he had no wound, and there were many serious cases needing attention. In the morning he arrived at the dressing station just as the ambulance was leaving and was put straight in. I regret that I did not see him. The patient was sent down on the early morning of the 11th to the 18th Field Ambulance, and told the medical officer that he had “shell shock.” His pulse was then 40 and temperature 97° F. He complained of pains in his head and back. On the same morning later he was admitted to

the casualty clearing station, where Lieutenant Dew observed rigidity of his legs and noticed that he was in a state of "cerebral irritability," calling out, "Let me alone." I (Captain Adie) was asked to see him on that day, but he could not be found by the sergeant-major, so, having several other cases to see, I did not see him until the next day.

On the morning of September 12th he was seen at 11 A.M. by Captain Dennis and Captain Stokes. He was lying flat, his abdomen was rigid; he showed total flaccid palsy of both legs and arms. A feeble extensor response (easily fatiguable) was obtained from the right sole, no response from the left. The cremasteric reflex was absent on the right side; was present, but easily fatiguable, on the left side. The abdominal and patellar reflexes were absent. The sphincters were not paralysed. His breathing was shallow and laboured. The ribs were motionless. Sensation was completely absent on the limbs and on the trunk up to apparently the second cervical level, but his mental condition was too bad for the results to be very reliable. Heat and cold were indistinguishable.

At 12.30 P.M. I saw the patient. The orderly reported to me that the patient was continually asking to have his position shifted. I saw him propped up, when his abdomen was flaccid. He was obviously near death, and it was difficult to get much from him. He protruded his tongue normally at request. He complained of feeling sick and of being unable to get his breath; "I am tied up," he said. Speech normal. Total intercostal palsy. Pulse full, slow, 54. Complete flaccid palsy and anæsthesia of all limbs. Plantar response: left leg, normal; right leg, faint flexion of proximal phalanges. No difficulty in swallowing. No incontinence or retention of urine or fæces. Unable to get any history from him. He died at 1.30 P.M.

*Post-mortem* examination at 2.15 P.M. by Captain Stokes. Slight but not definite mobility of the fourth cervical vertebra. No dislocation or fracture of vertebræ found. No external wound. A good deal of intravertebral hæmorrhage while getting out the cord (? normal bleeding from venous plexus). No clot in the vertebral canal. Some hæmorrhage within the upper part of theca, but this probably got in from the cut end. Hæmorrhages within cord in mid-cervical region and possibly in upper dorsal region. Cord preserved in 5 per cent. formol.

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*Description of Cord by Dr. Mott* (September 17th, 1915).—There are visible hæmorrhages in upper cervical region, extending about 1 inch on external surface of dura mater. On reflecting dura a subpial hæmorrhage can be seen  $\frac{1}{2}$  inch in length,  $\frac{1}{4}$  inch in breadth, over posterior surface of the cervical cord beneath the pia-arachnoid. The central canal at the level of the third cervical and about the level of the middle of subpial hæmorrhage contains blood about the size of a large pin head. This can be traced down to the upper part of the fourth cervical, and at the level of the lower part of the fourth cervical segment there is an obvious extension of the hæmorrhage into the right anterior horn. At the level of the fifth and upper part of the sixth cervical the hæmorrhage apparently extends throughout the whole of the grey matter. At the seventh cervical there is an obvious change in the grey matter, but the hæmorrhage is much less extensive. At the eighth cervical there is an apparent change in the whole of the grey matter, also in the first dorsal. The outline of grey matter becomes more distinct about the third dorsal, but throughout the dorsal region the naked-eye appearance suggests the probability of some change in the grey matter. Even in the lumbo-sacral region the grey matter does not appear quite normal in its outline. Subsequent microscopic examination of sections showed that the changes seen in the outline of the grey matter above described were due to some congestive oedema.

*Histological Examination of the Spinal Cord.*—The spinal cord was hardened in formol and cut after embedding in celloidin. Sections were cut and stained by van Gieson, Weigert Pal, and Nissl methods. The appearances presented corresponded with those described by Colonel Gordon Holmes in gunshot injury of the spine without penetration of the dura mater but causing concussion of the spinal cord. (*Vide* Plates IX–XI, Figs. 19–23, with descriptive text). It is presumed, as there was no visible sign of injury, that the man was struck on the neck by a sandbag, for he was partially buried. It is difficult to account for the limited area of the lesion by the blow of such a bulky object as a sandbag, and there was no evidence of dislocation of the vertebræ. The fact that the subpial hæmorrhage was over the posterior column, and the damage affected especially the posterior column and the grey matter, suggests that a pressure wave of the cerebro-spinal fluid was set up by the concussion, and the grey and white matter lying between the fluid in the central canal and the subarachnoid received the full force of the

PLATE IX.

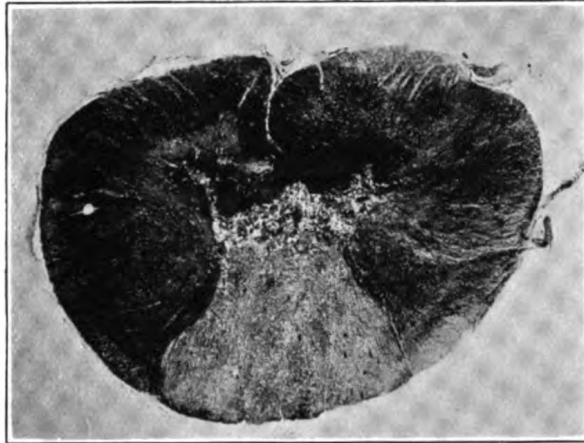


FIG. 19.—Section of the fifth cervical section of spinal cord of Case 2, spinal concussion without evidence of external injury. Observe the appearances of the grey matter and the posterior column, and the antero-lateral column of one side as compared with Figs. 20 and 21. This is at the seat of concussion. (In Figs. 19, 20, and 21, Weigert-Pal staining was employed.)

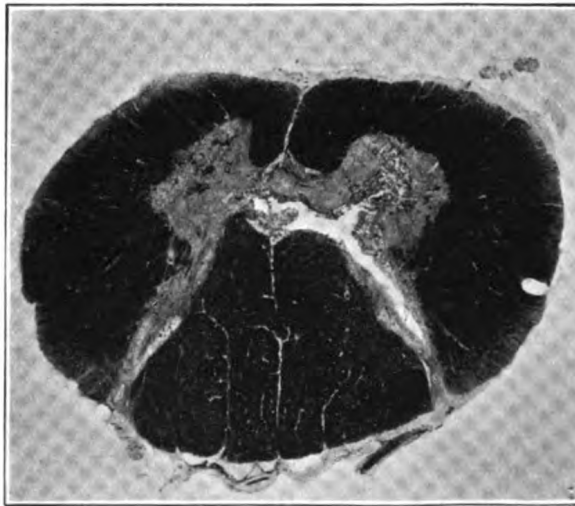


FIG. 20.—Section of the fourth cervical segment; observe the cavitation of the grey matter starting from the central canal and extending into the anterior horn and down the posterior horn of one side. It is only in these two fourth and fifth segments that gross macroscopic changes can be observed.





[To face p. 28.]

PLATE X.

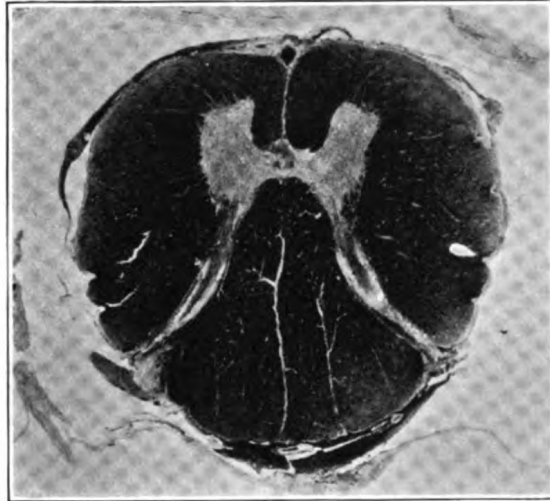


FIG. 21.—Section of the third cervical segment. No gross macroscopic changes are observable.

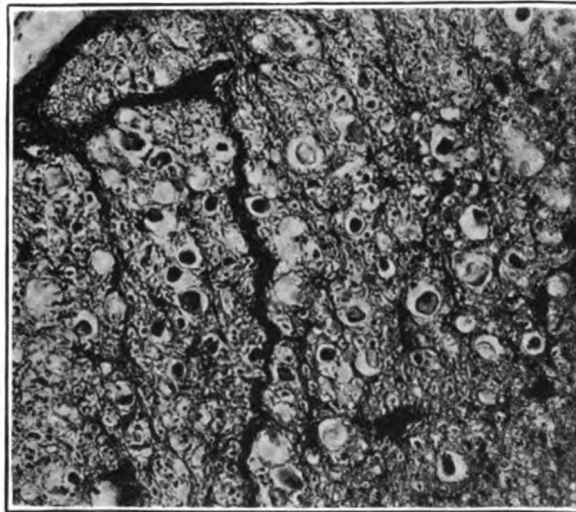


FIG. 22.—Section of periphery of posterior column at the level of the fifth cervical segment. Vacuolation of myelin sheaths and many swollen axons are seen. (Magnification 300.) Van Gieson staining.



PLATE XI.



FIG. 23.—Longitudinal section of periphery of posterior column at the level of the fifth cervical segment; the dark stained swollen axons are seen. (Magnification 200).

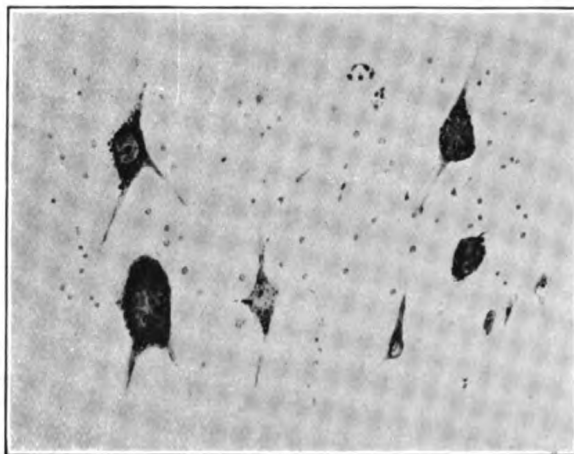


FIG. 24.—Section of third cervical segment of spinal cord case of concussion, stained by Nissl method, showing the median group of anterior horn cells corresponding to the nucleus diaphragmaticus, and they show a certain amount of perinuclear chromatolysis, but all the cells exhibit the Nissl granules. Even at the seat of concussion, the fourth segment, an external group of cells remain showing Nissl granules. Concussion, therefore, does not destroy the Nissl granules. Probably the cells of the nucleus diaphragmaticus show a certain amount of chromatolysis because they were continually discharging impulses along the phrenic nerves, and the few cells that were left of the nucleus had therefore much more work to do. (Magnification 300.)

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shock. Had it been a segment higher, instant death from complete destruction of the phrenic nucleus would have occurred. As it is, the microscopic examination shows that a partial destruction of "nucleus diaphragmaticus" took place. (Plate XI, Fig. 24.)

Dr. Sano, who has made a special study of the origin of the phrenic nucleus (diaphragmaticus), has been kind enough to look at these sections and indicate exactly the group from which the nerve arises: it is the median group of the anterior horn. These cells are entirely destroyed in the fourth and fifth segment, but are present in the third. They show, however, as compared with the other ganglion cells in the anterior horn at this level some chromatolysis, as if under the stress of increased activity the basophile kinetoplasm had undergone some disintegration without corresponding reintegration. The posterior column at the seat of the concussion presents a diffuse sieve-like vacuolation of the myelin fibres, such as have been described by Gordon Holmes. One sees also the enormously swollen axis-cylinders. This also is seen well in longitudinal sections (*vide* photomicrographs). The shock may have been so great as to have killed the axoplasm; for, as Leonard Hill, in a letter to me, says: "A water pressure of between 300 and 400 atmospheres kills all protoplasm (excepting deep-sea fishes). Water enters into the muscle and swells it and turns it opaque. There are curious fractures produced in the muscle fibres. The myelin of nerve fibres is broken up by the water entering into these." Then he goes on to say: "In the case of a high-velocity bullet striking the spine, it seems possible that the cerebro-spinal fluid beneath the struck part may be instantly compressed and act as a solid body transmitting the blow to the cord. There cannot be time for the fluid to be displaced. There is, anyway, a water-pressure limit beyond which protoplasmic activity is destroyed, and I imagine bullets must produce this pressure, but I very much doubt whether air waves produced by shell-bursts can reach to such pressures as 300-400 atmospheres." It is quite possible that a sandbag hurled against the neck could produce this effect without producing visible injury. This sieve-like character of the white matter and the large swollen axis-cylinders are only found in the posterior column from the fourth to the seventh segment inclusive. There are hæmorrhages in the white matter of the posterior column as low as the seventh cervical.

Below this segment no hæmorrhages are seen in the white matter, but congestion and small capillary hæmorrhages are found throughout the grey matter of the spinal cord. Since only about 48 hours elapsed between the concussion and death, there was no time for degenerative appearances of the white matter to occur; there was apparently a sudden destruction of a portion of the axons in the posterior column. No physical or chemical changes have occurred in their continuity above and below the seat of concussion, which certainly would be shown in the long fibres of Goll's column, where a large number of these greatly swollen axons and vacuolated myelin sheaths are seen. Although there are hæmorrhages at the seat of the lesion in the posterior column, the greatest amount of hæmorrhage is in the more vascular grey matter, and, as the photomicrographs show, the destructive disintegration is very marked at the level of the fourth and fifth cervical (*vide* Plate IX, Figs. 19-20); it is also seen to a less degree in the sixth and seventh. Shock, no doubt, interfered with the autonomic activity of the muscles of respiration below the lesion; it is remarkable that it did not produce a shock effect on the bulbo-spinal nuclei above. This shows how well protected they are from shock, also that a transverse lesion of the cord produces a shock effect down the efferent projection fibres and not up the afferents. It is noteworthy that this undoubted case of spinal concussion without visible injury accords in the histological changes with those described by Gordon Holmes. The blood contained in the area of hæmorrhage in the posterior column would soon be absorbed and give rise to the cavitation observed by Holmes in this region.

Now, contrasting this case of undoubted spinal concussion, in which the man was excavated within five minutes of burial and in which there was no loss of consciousness, with Case 1, in which there was complete loss of consciousness, we find that in the latter there are multiple punctate hæmorrhages of varying size in the white matter and the basal ganglia especially, and this condition we might explain by a blow of a sandbag on the head. The cause of the hæmorrhages being found especially in the white matter, on the supposition of the lesions being due to concussion, might be attributed to the fact that the ventricles are filled with the incompressible cerebro-spinal fluid to which the violent shock is transmitted.

Against this view is the fact that a careful search does not show



the swollen axis-cylinders, so characteristic a feature in the case of undoubted localised spinal concussion. The axis-cylinders arising from the large Betz cells in Case 1 are of the normal size; they are somewhat coiled up, but this is due to unequal shrinkage of tissue in the process of hardening and fixation (*vide* photomicrograph, Plate VIII, Fig. 17). Had there been cerebral concussion in this case of a similar nature to that in the case of spinal concussion, one would have expected to find swelling of the axons of the fibres of the internal capsule and corpus callosum, but a careful search revealed no such swollen axon fibres, nor was there any vacuolation.

The marked chromatolysis of the cells of the medulla, with eccentric position of the nucleus, have appearances corresponding with those found in a case of coal-gas poisoning, and they correspond to the appearances presented by cells deprived of oxygen by experimental anæmia as a result of ligation of arteries. The chromatolysis of certain groups of cells of the medulla is more marked than the chromatolysis of the cells of the cerebrum, where the hæmorrhages are more numerous and extensive. It may therefore be concluded that the cells of the vegetative centres—*e.g.*, respiratory and cardiac centres—are more exhausted. The store of basophile substance (representing neuro-potential) has been in great measure exhausted.

I have referred especially to CO poisoning, but there may also be poisoning by oxides of nitrogen. Nitric oxide would, however, act more as an irritant poison on the respiratory passages, setting up pneumonia. It has been noticed also that pneumonia is very liable to supervene on CO poisoning. The woman admitted to Charing Cross Hospital, comatose and suffering from carbon monoxide poisoning, died of pneumonia four days after admission, never having regained consciousness.

As it might be thought that the cases of nickel carbonyl poisoning are not really a fair comparison for carbon monoxide poisoning, I have compared the appearances of the cells of the cortex and medulla with those of the woman who died four days after inhalation of illuminating gas, and whose blood showed during life the characteristic spectrum of CO. Now, although the hæmorrhages in the cerebrum are not so extensive as in the case of shell shock with burial, the microscopic appearances are similar in the two cases. The microscopic appearances of the medulla oblongata in the two cases are very similar; there are no gross naked-eye hæmorrhages,

but sections stained and examined microscopically show markedly congested vessels, hæmorrhage into the sheaths, and subpial hæmorrhages, and there are small microscopic capillary hæmorrhages observable. All the cells, large and small, in the medulla oblongata of both cases, the gas poisoning and the shell shock with burial, show similar appearances of chromatolysis and disappearance of the basophile staining substance (*vide* Plate V, Fig. 11, and Plate VIII, Fig. 18). The nucleus is enlarged and clear, the intranuclear network and the nuclear membrane are distinctly seen, and the nucleus is more often eccentric than not. Only a few of the larger multipolar cells of the somatic nuclei show any Nissl granules, and then they are less numerous than in the normal cells, and there is often a tendency for the chromophile substance to exist in the form of irregular shaped granules or a fine dust. If it can be assumed that the amount of this stainable substance which forms the Nissl granules is an indication of the amount of kinetoplasm in the neuron, then in both cases there is a universal disappearance of this substance both in known CO poisoning and the case of shell shock with burial. The cause of this change in the gas poisoning is due to vascular stasis and lack of oxygen, and it is a reasonable hypothesis to suppose that the similar change in the medulla in the case of shell shock with burial and possible exposure to CO may be due to vascular stasis and lack of oxygen due to inhalation of sufficient CO to produce fatal effects before excavation could be effected. At any rate, this case suggests the desirability of examining the blood during life for CO in severe cases of shell shock without visible injury and where burial has occurred, and especially if some time has elapsed before excavation. This is all the more desirable, seeing that the possibility of CO being produced in sufficient quantities by the imperfect detonation of high-explosive shells to cause poisonous effects is admitted by those competent to judge.

#### MENTAL AND BODILY CONDITION OF THE INDIVIDUAL AT THE TIME OF RECEIVING THE SHOCK.

Having thus discussed the various causes which may act upon the central nervous system as the direct outcome of the detonation of high explosives, I will pass on to a consideration of the mental and bodily condition of the patient at the time of receiving the shock of the explosion. Before, however, considering this, the

personal factor, I will recapitulate the possible effects of the detonation of high explosives on the nervous system in cases where there is no visible external injury. They are: (1) Commotion from the aërial compression; (2) Concussion with or without burial; (3) Decompression with embolism, by bubbles of N and CO<sub>2</sub>; (4) Inspiration of CO during the aërial compression; (5) Prolonged inhalation of noxious gases—*e.g.*, CO—while lying unconscious or partially buried.

The mental and bodily condition of the individual at the time of the shock may be classified as follows:—1. Inborn: (*a*) A timorous disposition and an anxious temperament; (*b*) a neuropathic or psychopathic inheritance. 2. Acquired: (*a*) A *locus minoris resistencie* in the central nervous system in consequence of alcoholism, syphilis, or previous head injury; (*b*) a lowered neuro-potential, the result of a post-febrile neurasthenia; (*c*) nervous exhaustion, the result of mental stress, anxiety, insomnia, and terrifying dreams; (*d*) bodily exhaustion from fatigue, cold, wet, and hunger.

The signs and symptoms of shell shock are various, and with the exception of the profound effect on consciousness and memory in severe cases accord in the main to those of the two common types of functional neurosis, hysteria and neurasthenia. I prepared the following table from notes made by Dr. Cicely May Peake on cases admitted to Grove Lane Schools during six months:—

I. History reported on in 156 cases (shock).	
II. No history „ „ 80 „ „	
III. No history of shock in 40 „ „	
I.—A. History predisposing to shock in 111 cases; B. No history predisposing to shock in 45 cases.	
	Cases.
A. ( <i>a</i> ) Nervous predisposition (previous nervous breakdown, timid disposition, neuropathic temperament as family history, etc.) ... ..	52
( <i>b</i> ) Epilepsy (pre-war 20, since war 5). Of the latter, one had head injury and two bits of bone removed in 1904, and one developed fits after shrapnel wound of head (frontal) trephined during war ... ..	25
( <i>c</i> ) Shock or accident (pre-war) ... ..	11
Traumatic (pre-war) ... ..	9
( <i>d</i> ) History of insanity (patient 2, family 7) ... ..	9
( <i>e</i> ) Mental defectives ... ..	5
(3642)	c

It will be observed that a large majority of the cases of so-called shell shock admitted with functional neurosis in some form or other occurred in individuals who either had a nervous temperament or were the subjects of an acquired or inherited neuropathy. In a certain number of cases the cumulative effect of active service, often combined with repeated and prolonged exposure to shell fire and projectiles containing high explosives, had produced a neurasthenic or hysteric condition in a potentially sound individual. Some of the worst cases have occurred in soldiers and non-commissioned officers of years' standing—men of excellent physique who have led active lives without any evidence of a nervous breakdown; some, indeed, have fought in the South African War, and in this campaign had been in many battles and engagements without previously exhibiting any neurasthenic symptoms, but at last the nervous system gives way. Such men have not, as a rule, succumbed from a single "shell shock," unless it was one of the big "Jack Johnsons," but only after a third or fourth, and when they have been run down with the stress and anxiety of continuous apprehension and dread of the enemy surprising them. On the other hand, there are "the more or less rapid breakdowns," who give usually a history either of previous head injury, or of a nervous breakdown in ordinary life, or after some special stress indicative of a nervous temperament or of a neuropathic disposition. Among the large number of officers I have seen sent back on account of neurasthenia, a considerable number associated with shell shock, I have not observed a single case of functional paralysis or mutism.

Although the shock of shell fire cannot introduce the spirochætes into the brain, yet the commotion caused by the explosive and the depressing conditions of trench warfare might lower the resistance and enable the latent spirochætes to take on active development, causing meningo-encephalitis and paralytic dementia. The following case was of interest:—

A young man, aged 26, with unequal pupils, sluggish reaction to light and strangeness of conduct, was admitted to the 4th London General Hospital under my care. By the fact that he had Hutchinsonian teeth I thought that he might be suffering from juvenile general paralysis of the insane. An examination of the cerebro-spinal fluid gave a positive Wassermann reaction and lymphocytosis, which confirmed the diagnosis.

Cases which were said to have developed epilepsy as a result of shell shock were, generally speaking, individuals whom it might fairly be assumed were either epileptics or potential epileptics prior to the shock. It was judged that they were epileptics or potential epileptics by the fact that they had attacks of fainting, *petit mal*, or dizziness prior to the war. Some gave a history of automatic wandering, but it is quite possible that the dazed condition which may ensue from exposure to explosive forces may lead to such conditions, for which they could not be held responsible or be treated as deserters. Much depends upon whether they know the quality of their acts at the time. It will be observed that out of 25 cases of epilepsy there were only five in which there was not some pre-war evidence, and of these two might be associated with head wounds.

#### EPILEPSY.

My colleague at the 4th London General Hospital, Dr. James Collier, in a recent discussion at the Royal Society of Medicine on "Shell Shock without Visible Injury," stated: "I do not think psychopathic and neuropathic antecedents are of importance as determinants of functional manifestations following shell shock. What seem more important are the proximity of the explosion and the violence of the sensory effect, provided consciousness be retained." He then went on to say, "Major Mott has referred to epilepsy occurring *only* in those who had previously had fits or in whom there is a family history of the disease." What I did say was: "Cases which were said to have developed true epilepsy as a result of shell shock, the history showed, were *nearly always* individuals who had previously suffered with true epilepsy or an anomalous form of it, or that they were potential epileptics prior to the shock might be assumed from the fact that they had suffered with slight faints or automatisms, or that there was a history of epilepsy or insanity in the family." Dr. Collier rightly and justly points out the importance of this from the point of view of allotting compensation. I therefore have carefully summarised the pre-war histories of all the cases of epilepsy under my care who had been returned from the front since June. I am enabled, from the very careful notes taken for me by Dr. Cicely May Peake, who for six months has devoted her whole time to investigating these functional cases for the Medical Research Committee, from whom she received a grant, to show that my statement was based upon facts.

I have been studying for ten years the subject of hereditary predisposition of epilepsy and insanity, and the several hundred pedigrees which I possess make me certain that, of all nervous diseases, epilepsy is the one in which an inborn tendency is shown more than in any other nervous affection. I do not wish to imply that shock may not be a potent exciting or aggravating cause, but I am of opinion that "shell shock" is not *per se* the cause of epilepsy in the majority of cases. This question is, as Dr. Collier states, of great importance in deciding whether a pension should be granted. Now epileptics are not admitted to the army, if it be known, and they are required to state that they have not suffered from epilepsy. Many do not know, but some wilfully conceal the fact that they had previously had fits, or they may think they have been cured. Again, a man may know that if he can claim that he is an epileptic his services will be no longer required, and he can state that the shell shock was the cause, and claim a pension for being incapacitated by active service. This question of epilepsy being caused by shell shock is one which deserves very careful investigation and attention, and for this reason I have given here brief details of all the cases of epilepsy under my care, the subjects of which have been to the front. The facts may stimulate others to make careful inquiries before assuming that shell shock was in a particular case necessarily the cause *per se* of epilepsy.

*A Brief Summary of Pre-War History in 25 Cases of Epilepsy.*

CASE 1. Private ——. Mother had fits five years, only a few. Brother had few convulsions at 5 years of age.

CASE 2. Private ——. Had fits at home and his medical attendant who saw one said they were epileptic. He did not bite his tongue, but had a handkerchief in his mouth when he came to. His father had fainting fits once a week regularly on Sunday afternoons.

CASE 3. Private ——. Mother, now dead, had fits; does not remember any other relative with fits. Has never gone sick, and would not have done so now only "the doctors came on the scene when he was taken."

CASE 4. Private ——. Had fits before, when he went to school. Had seven or eight, the last at 13 years. Mother had fits; none

since she was 30. Two sisters had fits ; one has them still at 31 ; she bites her tongue.

CASE 5. Private ——. Was operated on for stone in kidney in 1912 (twice), and had five "hysterical fits" between the two operations.

CASE 6. Private ——. Had fits as a child, used to pass urine in them, and often hurt himself. Had no fits for 18 months before he joined the army.

CASE 7. Private ——. He had little schooling because from the age of 6 or 7 he suffered from seizures. He lost consciousness, fell down (hurt his head occasionally). Never bit his tongue or passed urine while in the fits. He had no more after 12. When he joined the army he told the medical man. He had seven more seizures at Aldershot. Father and one sister had "seizures."

CASE 8. Private ——. Had fits every other week before injury and five in a week afterwards. Had them from 9 to 10 years ; sister had fits also and bit tongue.

CASE 9. Lance-Corporal ——. Had a similar fit when aged 18. He was picking up a jug of water to wash with, dropped it, and lost consciousness. Did not bite tongue or pass urine during the seizures. One uncle very nervous.

CASE 10. Private ——. Began to have fits at 18. Always had blood in his mouth when in a fit, and had often passed urine when he came to. Sometimes he is free for three or four months at a time. Scars on tongue.

CASE 11. Lance-Corporal ——. Seven years ago had an epileptic fit. Before rejoining was in Garrison Artillery ; left it because he failed in an examination. Says he was unconscious when in a fit ; saw everything going round and breathed fast. Did not bite tongue or pass urine.

CASE 12. Private ——. Suffered from epileptic fits as a child, but never had one since he was 6 years of age.

CASE 13. Private ——. Had a few fits in civil life, about a dozen ; began when he was 16. One brother had nervous breakdown.

CASE 14. Private ——. Had a fit before enlisting. Says he would have denied it if any question had been asked.

CASE 15. Private ——. He had been picked up unconscious on the Palace Pier, and knew nothing till he was in hospital next morning. In the trenches and while in training he sometimes found he had lost himself for a few minutes. These fits lasted about ten minutes.

CASE 16. Private ——. In England, after long marches, he four times had a fit; bit tongue, but did not pass urine. Had two or three fits in civil life over a year ago. None before that. Was always frightened of motor cars.

CASE 17. Private ——. Had fits (about 20 altogether) from 7 to 17 years of age. These came on in hot weather. He felt dizzy beforehand, then fell, struggled, was unconscious about 15 minutes, and had headache afterwards. Always fell, never hurt himself, never bit tongue or passed urine. Thinks his mother used to have fits.

CASE 18. Sergeant ——. Had one fit in South Africa.

CASE 19. Private ——. Has had three fits in civil life between ages of 19 and 21. Bit tongue and passed urine in all three. One sister has had several fits.

CASE 20. Private ——. Had fits as a child.

CASE 21. Private ——. Has scar on forehead—depression of skull the result of a blow from a swing-boat, which fractured his skull. Has had several fits since enlistment.

CASE 22. Rifleman ——. No family history of fits; no previous history of epilepsy.

CASE 23. This patient began to have fits after getting his head compressed between two coal tubs in the pits. After this accident he was ill for a month. A sister had epileptic fits.

CASE 24. Gunner ——. No family history of fits.

CASE 25. Private ——. No family history of fits. Linear scars of operation over frontal region with trephine hole which has shelving edges.

It will be observed that out of 156 cases in which a previous history is reported in the notes, 52 gave a history of either a previous nervous breakdown or a timid disposition, easily frightened, emotional, or afraid of the sight of blood; in a few, the fact was elicited that they had had a fright in early childhood



and that this recurred in dreams. Some gave a history of a neuropathic tendency or inheritance. So that all the evidence goes to prove that an acquired or inborn tendency to neurosis plays an important part in the effects on the central nervous system of exposure to shell shock in a majority of the cases.

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### LECTURE III.

MR. PRESIDENT AND GENTLEMEN,—In my first lecture I dealt especially with the factors that are held responsible for the various functional neuroses and psychoses occasioned by the physical forces generated by high explosives; and in my last lecture I dealt with the possibility of noxious gases playing an important part in the production of severe symptoms in cases of shell shock with burial in which there was no visible injury. I also brought forward statistical evidence to show that an inborn or acquired neurotic disposition was a very important factor in promoting the onset of a neurosis or psychosis and in determining the duration and severity of the symptoms.

The varying groups of signs and symptoms indicative of loss of functions or disorders of functions of the central nervous system arising from exposure to forces generated by the detonation of high explosives are classed under the term "shell shock." In a large number of cases, although exhibiting no visible injury, "shell shock" is accompanied by "burial."

### SYMPTOMS.

From the point of view of compensation or pension, the War Office authorities very properly regard "shell shock" as a definite injury, although there may be no visible sign of it. This fact is of considerable importance, for, as in the case of pension or compensation for traumatic neurasthenia under the Employer's Liability Act, the notion of never recovering may become a *fixed idea*. The detection of conscious fraud is not easy in many cases of "shell shock" in which recovery might reasonably have been expected, for it is difficult in many cases to differentiate malingering from a functional neurosis due to a fixed idea. The first point is to be sure of your diagnosis that the disease is altogether functional, and,

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being satisfied thereof, to avoid all forms of suggestion of the possibility of non-recovery. A very great difficulty in the complete investigation of these cases arises from the fact that few or no notes, as a general rule, accompany the patients; one has therefore to rely upon the statements made by the patient himself, or perchance of a comrade, if he has no recollection of the events that happened. Most of the cases of shell shock, however, are able to give satisfactory information of the events that preceded the shock; they even tell you they can call to mind the sound of the shell coming, and see it, in the mind's eye, before it exploded; then there is a blank in the memory of variable duration. In some of the more severe cases, especially where there has been burial or physical concussion by a stone or a sandbag, or by falling heavily on the ground after being blown up in the air, there is a more or less complete retrograde amnesia of variable length of time. In a case of simple shell shock it is impossible to say whether the patient was unconscious during the whole period of time of which he has lost all recollection of the events that happened, or whether during the whole or a part of the time he was conscious, but, owing to the "commotio cerebri," the chain of perceptual experiences was not fixed. In the majority of cases "shell shock" affects only the higher cortical centres; in severe cases the vital centres, as in apoplexy, alone continue to function, or the patient is only in a dazed condition, and he may automatically perform complex sensori-motor purposive actions of which he has no recollection whatever. Several cases of this kind have come under my notice, but I will describe only one of the most reliable, as it is a history obtained from an officer:—

His company had dug themselves in in a wood; he went out into the road to see if a convoy was coming, when a large shell burst near him. It was about 2 o'clock in the morning and quite dark; about 4.30 A.M. it was quite light, and he found himself being helped off a horse by two women who came out of a farmhouse. He had no recollection of anything that happened between the bursting of the shell and this incident. It is interesting to note that it is possible for him to have inhaled noxious gases, for the single cigarette in a metal case that was in his breast pocket was yellow on one side, due, no doubt, to picric acid contained in the explosive.

All degrees of effects on consciousness may be met with, from a

slight temporary disturbance to complete unconsciousness, with stertorous breathing continuing till death. Occasionally cases have been admitted under my care at the 4th London General Hospital who had not yet recovered normal consciousness, and for some days were in a dazed, somnolent, or even semi-conscious condition. Usually these cases came at a time when large convoys were sent from the front owing to a recent engagement. The histories of cases sometimes showed that following "shell shock" men occasionally absented themselves, and, wandering away from the trenches, were found in a dazed condition, unable to account for their actions or to recollect how they came there. This condition is not unlike a fugue or automatic wandering of an epileptic; and, indeed, in some of these cases there was a history of epilepsy or a predisposition to it, but in others no other cause was ascertainable than the conditions which induced "shell shock."

*Cases of Automatic Wandering and Temporary Mental Confusion.*

Private C. J. To France, October, 1914. Was in a shell and bomb explosion at Festubert in May, 1915, when five men were wounded and ten of his company killed. He was half dazed for about five minutes, then got up and went about his work. Reported sick to get some teeth, and was sent to convalescent camp. Then he absented himself from duty, not realising that he had committed a crime. He stayed till he felt his mind right and then returned. He was deprived of his stripe but not punished further, as he realised when he came back what he had done. He has had 16 years' regular service and says he had these attacks in India.

Private A. J., aged 23. To France, March 16th, 1915. Exposed to prolonged shell fire. No special shock. Was off food, could not sleep, and had pains in the stomach and back. He remembered going and lying down in a field. About two days after woke up in a hospital. He can recollect nothing of what happened between. His head was spinning; he could not sleep nor see properly; he dreamt of trench warfare and bursting shells.

Now it is a fact that trauma accompanied by horrifying circumstances, causing profound emotional shock and terror, has a much more intense effect on the mind than simple head injury would cause, in spite of the fact that for some time after the injured man may be unable to recall the circumstances.

A young lieutenant was admitted under my care suffering with acute chorea. There was no rheumatic history; he had a bruise over the left forehead; he complained of terrifying dreams. He remembered nothing that happened between his arrival at Havre and his return to consciousness at the hospital in Boulogne except a vague notion of arms and legs flying in the air, of which he frequently dreamed. I ascertained that he had been at Hill 60, battle of Neuve Chapelle. His brother had received a letter from him telling him that he was moving to the front, but he had no recollection of having written this letter. He could recall nothing that happened after his arrival at Havre. Reading the newspaper, he saw the word Bailleul; he said he was familiar with the name as a place he had been at, but it was merely a word association, for he had no recollection of the place nor of anything that happened there. Some of the terrifying dreams this patient had were based upon incongruous association of past experiences. Thus he was troubled especially by this dream: He and his company were charging up an inclined plane; when they arrived at the top a gigantic Prussian sat down and swept them all back. After playing billiards he dreamt that Prussians were pelting him with red-hot billiard balls. The terrifying dreams in this case persisted for months. But the only recollection he has of experiences during the period of anterograde and retrograde amnesia was of arms and legs flying in the air, of which he has a vague recollection.

#### AMNESIA.

Memory is the storing away of perceptual experiences out of consciousness, and recollection is reviving by will and association the images of those experiences in consciousness. Some of these patients after they have recovered from the shock and are convalescent are able to revive in consciousness the events which happened. A great psychic feature of "commotio cerebri" from shell shock is the resulting inability of the brain to exercise sustained attention on account of the mental fatigue which occurs, and rest is imposed by the feeling of weariness and various forms of headache or discomfort. Again, irresolution and indecision is a frequent result of shell shock, whether induced suddenly or after prolonged exposure to shell fire and the stress of trench warfare. This is a serious disability in officers and non-commissioned officers placed in positions of responsibility. The condition is often

aggravated by insomnia, anxiety, and worry, for they are quite conscious of their mental disability and filled with apprehension of making mistakes. Commanding officers often show commendable discretion in sending such men home for leave and thus avert a serious nervous breakdown.

Loss of memory may be a complete loss of power of recollection and of recognition. Consciousness, except for the immediate present perception, may be a blank, and there is in such cases, as a rule, no art to find the mind's complexion in the face, for a patient so afflicted exhibits a dazed, mindless expression. Three cases in particular I will cite as exhibiting this intense form of amnesia.

One case was a sapper who upon admission could give no information himself; we learnt from a comrade he had been blown up in a trench. He could not recollect his own name; he did not recognise his name when it was written; he did not know the season of the year; he could not recognise any coins except a half-crown, but he possessed this coin which had just been given him. He did not recollect anything that was told him, so that his memory for recent events as well as for the past was lost. He had a dazed expression, exophthalmos of the right eye, and enlargement of the thyroid, especially of the right lobe. This man rapidly improved and recovered completely.

Another case was remarkable in several ways.

The patient's mind was a complete blank, and this condition was reflected in a dazed, mindless, mask-like expression. When asked where he lived he said W—; he did not know it was in the West Riding. He did not know the address of his home, and when shown a letter from his father with the address on the top he did not recognise it or his father's handwriting. When shown a photograph of his home with a group of his father, mother, and three brothers and himself in front of it, he maintained the same wondering, dazed expression, and failed to recognise the nature of the picture. His father had heard from a comrade that he had been buried by the explosion of a shell in the trench; he had been unconscious for some time and lost his speech. We heard from his father that he was a good musician, and I said to him, "G—, I hear you are a good musician," and I asked him if he could play the piano or sing; there was the same wondering, bewildered look, and he muttered something which was to the effect that he could

not sing or play. Three days later I said, "Come, you can whistle 'God Save the King.'" He took no notice, but upon pressing him he looked up and a glint appeared in his eyes, and he said, "You start me." I whistled the first bar, he took it up, and whistled it admirably. I then asked him to whistle "Tipperary," but he could not do it till I started him, and the same with several other tunes, but once started he had no difficulty, and I recognised from the admirable intonation that he was, as his father described him, an excellent musician. I could not, however, that day get him to start upon his own initiative any one of the tunes he had whistled. The next visit, three days later, I observed that his expression had changed. He smiled when I spoke to him, and I recognised clear evidence of a mind that had partly found itself. He could now whistle any of the tunes I had previously started him on by himself when I called for the tunes. I then said, "Come along to the piano." He came, and I got him to sit down in front of it. I said, "Play." He looked at the instrument with a blank expression, as if he had never seen such a thing before, and I could not get him even to put his fingers on the keys. I then took one of his hands, and, holding his forefinger, I made him play the melody of "Tipperary." He looked at me, and again I noticed a glint in the eye and a change of his blank expression indicative of association and recollective memories. He put his other hand on the keys and played a few chords. I went away feeling confident that his musical talent would reveal itself. He played for half-an-hour while I was in the ward without a single discord. The next time I came he was able to play any music set before him. His associative memory and recollection of music was in advance of other associative memories. Thus, eight months after he had recovered his musical memory, he had very imperfectly recovered his memory of elementary facts regarding his profession of a land surveyor—*e.g.*, he could not tell me how many poles there were to a rood—and there was still a tendency to a vacant mindless expression and prolonged reaction time as shown by delay and slowness in responding to questions as if there were a difficulty in linking up the necessary associations.

This early return of the musical memory happened also in another severe case of amnesia, which I will briefly relate.

This patient was admitted for shell shock. He had almost a

complete loss of recollection of all the incidents of his past life except some experiences of early life, such as where he went to school. His powers of recognition were limited to knowing his parents. He had a bewildered vacant expression and a slow reaction to questions; when interrogated his countenance assumed a puzzled aspect as of one trying to recollect. His memory for recent events was absent, and persons that he had frequently or daily seen he failed to recognise. After four months he had made but little improvement. His memory of the past seemed to show the first signs of awakening in the associations of music. He recollected musicians that he had heard and songs that he had sung, although, as in the above case, he remembered nothing of his professional occupation. He said that while with his friends he had been asked to sing songs which they said he had sung before—that he did not recognise them at all when he saw them, that after they had been played to him two or three times he was afraid to begin, as he felt he did not know them, but that, once he started, “he seemed to know without remembering” and got through quite well. One song he managed after it had been played through only once (“I Hear You Calling Me”). I learnt from an officer who had been a school-fellow of this patient that he had suffered with a head injury in early life. This may have produced a *locus minoris resistentiæ* in his brain.

Every state of consciousness which is habitually repeated leaves an organic impression on the brain, by virtue of which that same state may be reproduced more readily at any future time in response to a suggestion fitted to excite it. But it may be asked, Why should the memory of music be more readily revived in consciousness than other experiences?—for example, those connected with the professions of these two young men before they entered the army. I should explain it by the fact that there can be no doubt that cognitions, whether pleasurable or painful, are more deeply graven on the mind and more firmly fixed in associative memory when associated with intense feeling. Music, of all the arts, appeals most to the emotions, and probably this is the reason why countless men and women, even the uneducated, can recall the words of songs and hymns when they hear the first bar of the musical setting.

Fixation and organisation of repeated experiences in the mind is

shown in music, for a song that has been sung a number of times only requires the first word or note for it to be continued to the finish without any effort of consciousness, the last note or word uttered serving as the appropriate stimulus of the next ; as in an instinct we have what is termed a chain reflex. This was strikingly exemplified in a soldier under my care who suffered with motor aphasia and right hemiplegia in consequence of a bullet wound of the brain.

The bullet entered the left side of the head and passed through the left fronto-central region of the brain and through the right orbit, destroying the eye ; it also in its passage must have cut through the left optic nerve or tract, for he was totally blind. This poor fellow was very cheerful and comprehended all that was said to him ; thus, by feeling my tunic sleeve he recognised my rank, for when asked if I was a captain he expressed negation by "oot," colonel also by "oot," meaning "No," and major by "ah." He obeyed all commands. Now, curiously enough, although he was able to express judgments only by "ah" and "oot," which correspond to Yes and No, he was able to sing several songs through without difficulty provided the first word or bar of music was given. Thus, I stood beside him and hummed "'Tis a long way," and immediately he started the well-known chorus of "Tipperary," winding up with "Are we downhearted ?—No !" I then said, "Say Tipperary, Tom." He replied "oot," and he was unable to utter any of the words. It must be concluded either that the song had been repeated so often as to have become organised in both halves of the brain or in subcortical lower centres. We know also that in amnesia rhymes are recalled very easily, especially if they have been learnt in early life. A month later, when I saw him, he was able to walk and speak. Thus, given a half crown, he felt it, then tried the rim for milling on his teeth, and said, "Two shilling bit." When asked again, he corrected it with "Half crown." Given a penny, he tested it in the same way, and the unpleasant taste left in his mouth caused him to throw it down with all the signs of disgust, saying at the same time "Copper."



## PSYCHIC TRAUMA AND THE EFFECTS PRODUCED BY TERRIFYING DREAMS.

The frequency with which these cases of shell shock suffer with terrifying dreams at night and in the half-waking state points to the conclusion that a psychic trauma is exercising a powerful influence on the mind by the thoughts reverting to the terrifying experiences they have gone through, and their continuous influence on the subconscious mind may account partially for the terrified or vacant look of depression on the face, the cold blue hands, feeble pulse and respiration, sweats and tremors, some or all of which signs of fear the severer cases manifest. As these dreams cease to disturb sleep, so these manifestations of fear tend to pass off and give place to the sweet unconscious quiet of the mind. Occasionally during the waking state contemplation of the horrors seen provokes hallucinations or illusions which may lead to motor delirium or insane conduct. At least that is the interpretation I should put upon the symptomatology of the two following illustrative cases:—

1. A captain, aged 20, was admitted under my care in a state of restless motor delirium; he moved continually in the bed, sat up, passing his hand across the forehead as if he were witnessing some horrifying sight, and muttering to himself; yet, when interrogated, he answered quite rationally. This motor delirium I associated with the continuous effects on the conscious and subconscious mind of the terrible experiences he had gone through. His whole company had been destroyed, and, while talking to a brother officer, the latter had half his head blown off by a piece of a shell. The patient improved very much, but a relapse occurred after a night disturbed by terrifying dreams. He recovered sufficiently in a week to go out.

2. *Paroxysmal Attacks of Maniacal Excitement Following Shell Shock.*—A young man, aged 19, was admitted from shock, due to emotional stress and shell-fire. He suffered with terrifying dreams, and after he had been in the hospital a short time he developed sudden paroxysmal attacks of maniacal excitement. The first attack occurred suddenly. One afternoon he had been helping as usual in the kitchen, and then he went and lay down on his bed and apparently went to sleep; he suddenly woke with a startled, terrified look, became flushed in the face, sweated profusely, and made for the door as if to get away from some terrifying conditions. He was with difficulty restrained. He remained in

this excited state, glaring rapidly from side to side, giving one the impression that he was suffering from terrifying hallucinations of sight and hearing, although he would make no response to interrogation. He did not recognise his wife, the doctors, or the sisters. Once when I, accompanied by two medical officers in uniform (strangers), came up to speak to him, he became violently agitated, as if some terrifying conditions had been aroused by the sight of the uniforms; the face was flushed and he sweated so profusely that the perspiration dripped in a stream off his nose. The attacks would last from a few hours to a few days; they came on quite suddenly like an epileptic fit, and often without any apparent cause. They became more severe and frequent, and when we had moved the neurasthenic patients to the Grove Lane schools, he one day ran out of the building into the playground and attempted to get over the wall. He was brought back, and I saw him sitting in the ward on his bed; his head was buried in his hands. I spoke to him; he immediately got up, looked at me in the most terrified manner, and made for the door; it required four orderlies to restrain him, and he fought and kicked violently, exhibiting great strength and nervous energy. Much to my regret I found it necessary to have him sent to Napsbury. I have heard that he has made a complete recovery and been discharged. It may be mentioned that there was no history of epilepsy or insanity in the family obtainable. The case rather suggests the psychic equivalents of epilepsy in the attacks.

Fear in its depressing effects upon the mind and body plays a very important part in the production of a neurasthenic condition. Constant apprehension and anxiety causing sleeplessness, loss of appetite and power of assimilation, are productive of a mental and bodily state by which the constant danger and fear of death induces terror, and this may in a few instances so profoundly affect some individuals as to turn the hair white in a few days. Thus, one patient of mine, a mute, after being ten days in the trenches, found his hair had turned white. He was only 26, but there was a family predisposition to early change of the colour of the hair to grey. This reminds me of the familiar lines of Byron in the "Prisoner of Chillon":—

" My hair is grey, but not with years,  
Nor grew it white in a single night,  
As men have grown with sudden fears."

We do not know whether his hair turned white in a single night at the sudden emotional shock that made him mute.

Terror is contemplative fear; it is fear made more or less permanent by the imagination fixing in the memory past terrifying experiences, repressed in great measure by conscious activity of the mind during the waking state, but evident in the dreams which afflict nearly all these soldiers suffering from "shell shock" and trench warfare. Shakespeare has clearly indicated how dreams influence the minds of men and how they are based upon past experiences. Thus, Mercutio, in the description of Queen Mab, refers to the soldier's dreams in the following lines, which are as true to-day as when Shakespeare wrote them :—\*

"Sometime she driveth o'er a soldier's neck,  
And then dreams he of cutting foreign throats,  
Of breaches, ambuscadoes, Spanish blades,  
Of healths five fathom deep; and then anon  
Drums in his ear, at which he starts and wakes;  
And, being thus frightened, swears a prayer or two,  
And sleeps again."

In addition to the revival of experiences of trench warfare, of hearing the shells burst and seeing the flash, of parapets being blown down, of being buried, of charging the enemy, soldiers often complain of a falling or sinking feeling; possibly it is to this that Shakespeare refers in the lines "of healths five fathom deep." Often in their dreams patients are heard to cry out and awaking find themselves in a cold sweat. Some officers have been heard to give commands to their men and urge them on to battle. Now it does not necessarily follow that these men who cry out or talk in their sleep and who obviously were dreaming can recollect their dreams; in fact, it is not a very uncommon thing for them to say they do not dream, although they say they have awakened with a start and found themselves in a cold sweat, indicating that they had been "thus frightened." A functional case of deaf mutism, who would narrate in writing his terrifying dreams, did not cry out as some mutes do, but systematically in his sleep went through the pantomime of bayoneting the enemy, and even would get out of bed and look under, and of this performance he remembered nothing. He did not do this when hypnotised. Under an anæsthetic soldiers sometimes may perform

\* Sir Arthur Downes has written to me that in the quarto 1597 the text had "countermines" instead of "Spanish blades," which seems singularly appropriate just now.

the pantomime of such habitual acts as of raising the gun to the shoulder and pulling the trigger. Therefore, when Shakespeare says, "Dreams are born of fantasy, children of an idle brain," he was clearly referring to those dreams in which experiences of the past are so dissociated and linked up in incongruous association as to require careful analysis in order to show their origin. I could cite many instances, but two or three will suffice.

An officer who had served in South Africa told me that he had had a dream from which he awoke in a fright. He was in a mine passage at the front when he met a leper who came towards him. Upon questioning him and asking him if he could recall some period of his life in which his mind had been disturbed by a leper, he remembered that he and his comrades were much alarmed and vigorously protested against a leper being allowed to remain in an adjoining sangar. Evidently this had left a deep impression graven on the mind, the principal subject, the leper, was dissociated from concomitant experiences in the South African War, and became linked up with a recent terrifying experience of being in a mine passage, which likely enough was also an experience in which the emotion of fear occurred. Both incidents suffused with very strong feeling tone in all probability were deeply graven on the mind and became firmly fixed by subconscious association.

A sergeant who had been a schoolmaster was asked to write down his dreams by Captain W. Brown, who has charge of my cases at the Maudsley Hospital. The first was as follows :—

I appeared to be resting on the roadside when a woman (unknown) called me to see her husband's (a comrade) body which was about to be buried. I went to a field in which was a pit, and near the edge four or five dead bodies. In a hand-cart near by was a *legless body*, the head of which was hidden from sight by a slab of stone. (He had seen a *legless body* which was covered with a mackintosh sheet, which he removed.) On moving the stone I found the body alive, and the head spoke to me imploring me to see that it was not buried. Burial party arrived, and I was myself about to be buried with legless body when I awoke.

The second dream was as follows :—

After spending an evening with a brother (dead 11 years ago) I was making my way home when a violent storm compelled me to

take shelter in a kind of culvert, which latter turned into a quarry situated between two houses. Men were doing blasting operations in the quarry, and whilst watching them I saw great upheavals of rock, and eventually the building all around collapsed (explosion of a mine). Amongst the *débris* were several mutilated bodies, the most prominent of which was *legless*. I tried to proceed to the body, but found that I myself was pinned down by masonry which had fallen on top of me. As I struggled to get free the whole scene appeared to change to a huge fire, everything being enveloped in flames, and through the flames I could still see the *legless body* which now bore the *head of my wife*, who was calling for me. I was struggling to get free when *my mother* seemed to be coming to my assistance, and I awoke to find the nurses and orderlies standing over me.

It appears that the patient had been shouting in his sleep, beginning in a low voice and gradually becoming louder until eventually he was shrieking. The *legless body* occurred in all his dreams; the sight of this had evidently produced a profound emotional shock. He had worried a great deal about his wife, who was much younger than himself, so that we have this incongruous association of the *legless body* and the *head* of his wife calling him; finally, who more natural than *the mother* to come to his help. The emotional complex is not incongruous in this dream, for fear is linked up with the tender emotion.

#### SPEECH DEFECTS.

Various forms of speech defects are common; they are mutism, aphonia, stammering, stuttering, and verbal repetition. The most frequent speech defect is mutism. About 1 in 20 of those admitted with a history of shock due to high explosives, and having no visible signs of injury, suffer with mutism, but, nevertheless, are quite able, as a general rule, to write a lucid account of their experiences. Most of the men so afflicted are unable to whisper or produce any audible sound; thus there is no sound when they laugh. They are unable to whistle or to cough, and in severe cases there is difficulty of putting out the tongue, and, in one case, of swallowing. About 35 cases of mutism have come under my observation; they have now all recovered. The following two very severe cases of "shell shock," which occurred in May, 1915, have only quite recently recovered their speech.

*"Severe Shell Shock" without visible injury except wound of wrist, unconscious three days, terrifying experiences and dreams, marked aspect of terror, mutism, weakness and in-coördination of upper limbs, inability to masticate or swallow at first, persistent loss of power in legs with anaesthesia and analgesia. No Babinski sign. Intelligence and silent thought unimpaired. Later recovered movement in upper limbs, and able to write. Complete recovery after eleven months, except sensation and movement in legs.*

Private W., admitted to 4th London General, May 15th, 1915. This patient is speechless ; he is lying in bed almost helpless. The eyes are wide open and have a pained, vacant stare, the brow is lined by many deep transverse furrows, and both the pyramidales and the corrugatores supercillii are strongly contracted, so that at the root of the nose vertical furrows meet the transverse folds of the forehead, caused by the contracted occipito-frontalis muscle. The nostrils are somewhat dilated, and the mouth partially open, the naso-labial furrow and the other lines of the countenance are for the most part obliterated, so that the expression is like to that of intense terror. The face is flushed and perspiring. The hands are blue and cold, and the pulse at the wrist is hardly perceptible. The feet are cold. He is unable to sit up by himself ; he cannot protrude the tongue beyond the teeth, although he made an effort to do so, and there were slight movements of his lips, as though he were attempting to articulate. He comprehends all that is said to him, and tries to make himself understood. He cannot masticate because he cannot open his jaw ; he has difficulty in swallowing, and at first there was considerable difficulty in giving him nutriment. Later, he was able to swallow jelly, lightly boiled egg and mince. He replies to questions by affirmative or negative nods of his head. He can read written and printed language, but when given a paper and pencil to write, so great was his difficulty in holding the pencil, and so pronounced was the tremor, that the pencil only marked a tangled skein on the paper, although it was evident that he was making an attempt to write. He cannot move his legs, which are rigid, and the right is decidedly more wasted than the left. There is patellar clonus and ankle clonus, but the plantar response was rather flexor than extensor. He has complete control over his sphincters. When I saw him a few days later he was better and playing draughts with another patient.

He could not take the pieces up, but managed to push them on to the squares. This patient was able to converse with him by the deaf and dumb manual. He said he had learnt this 16 days prior to admission. We also ascertained that his memory only goes back to the time he landed in England, but he had been told that two months previously a shell had burst near him and rendered him unconscious for three days; a fragment of it had also caused a wound on the wrist, a scar of which still existed. He had previously seen a sergeant and seven others killed by a shell. He had not had tetanus. He suffers with terrifying dreams. He is very intelligent. He can neither cough nor whistle nor blow out the cheeks.

At first there was a frequent tendency to regurgitate fluid or to vomit it. His swallowing has improved, likewise his circulation, but now, 10 days after admission, he has difficulty in swallowing; he cannot bend his legs, put out his tongue, or open his mouth, raise himself in bed, or turn without assistance.

*June 1st.*—Steady improvement in his circulation, respiration, and power of swallowing soft food. Still quite unable to move his legs. The transverse furrowing of his brow much less evident. He still dreams.

*June 7th.*—Tested his sensibility with a needle; for the most part he does not respond at all to pricking; occasionally he indicated that he felt, once on the inner side of the right thigh, once on the inner side of calf of right leg. He was told to nod, and hold up his left or right hand, according to the side stimulated. He responded once on the left side of abdomen, but when he did respond there was *marked delay*. He does not feel the head of pin, at least no response was obtained; nor did he feel the vibrating tuning fork on his limbs, although he responded with marked delay when put on his ribs or his forehead. But the vibration had to be of large amplitude. Tested with large tubes containing hot water and ice, he did not respond to the former, but he recognised the latter as cold, although there was considerable delay. A succession of sharp pricks in the same place on the limbs produced no response to stimulus. He now smiles or even laughs, but there is no sound accompanying the expansion of his features. He still is unable to blow or whistle or phonate, although he understands everything; he cannot write. There is marked spasticity of the lower limbs. The patellar reflex can just be obtained; there is no clonus. Ankle

clonus, not typical, is present. Plantar reflex: the only response is a slight flexor flicker of the little toes. The superficial abdominal reflex is just obtainable.

Respiration is less shallow; abdominal movements are observable, indicating descent and ascent of diaphragm, of the normal quiet breathing of the male.

He readily becomes fatigued; when he attempts to use his hands there is marked weakness and in-coördination. None of the muscles however, appear wasted. Captain Clayton tried strong faradic stimulation to the larynx but without any resulting phonation.

*August 2nd.*—Patient sat up; for the first time was helped to stand on his feet by two persons, one on each side, supporting him under the shoulder. When tested with tuning fork, there was a marked delay—10 seconds on the hands before he gave an affirmative nod, whereas, placed on the forehead, he responded immediately. The pharyngeal reflex is absent. He can now blow out a candle at a distance of a foot. There is no real tone in the cough. Never any difficulty with his sphincters.

*October 18th.*—He cannot feel below the knees. *He can now write quite well*; sitting on the wheel chair, he plays billiards and even Badminton. He is very happy, but cannot speak, whisper, or whistle. He is able to stand, supported on both sides, but cannot raise his foot from the ground, though he tried hard to do so.

*December 26th.*—Said "Paddy" once, and with great exertion managed to stand, but he cannot raise a foot from the ground. There is anæsthesia and analgesia of the legs as high as the knee. The muscles are not wasted.

*March 12th.*—He now speaks quite well. His speech returned in the following manner. He was sitting in his wheeled chair playing baseball, at which he was quite good, when a runner overturned him; the sudden emotional shock and surprise made him exclaim aloud, and since then he has quite recovered speech. But he cannot walk; there is still the stocking anæsthesia as high as the knee. He was consequently boarded out.

*"Severe Shell Shock": Blown into the air in trench; does not remember falling; aspect of terror, mutism and inability to phonate or to expire forcibly. Sudden recovery of speech eight months later.*

Private F. H., age 20, admitted 1st June, 1915.

*Appearance.*—Face flushed, eyes staring wide, pupils dilated,



forehead wrinkled, mouth partially open, all the lines in the naso-labial fold obliterated. Hands and feet cold and blue.

*Pulse* very small and feeble, hardly perceptible on left, just perceptible on right.

He comprehends what is said to him, and tries to put out his tongue, but it hardly comes beyond the teeth. The lips move slightly in attempts to speak. He can read, and answers quite rationally and intelligently by writing.

When asked how he was knocked out, he wrote :—"There was something dropped into the trench. I think it was a shell; I felt myself go up into the air, but I cannot remember falling. The next thing I remember I was in a farm with some doctors. I don't know how long a time there was between. I have not had any dreams."

He cannot whistle, he cannot cough, and cannot take a deep breath. The diaphragm, examined by X-rays, showed only slight movement of tranquil breathing, though he was told to cough.

He remained in this condition for a few days; his pulse and general condition improved.

He was transferred after three months to Morden Hall. He was told that he had adenoids, and that an operation would not only get rid of this trouble, but he could speak. He had the operation performed under an anæsthetic, but on recovery he did not speak. The suggestion had no effect. He was often depressed at finding others regain their speech, and he, unable. He was a good fellow, and tried to get well. His joy was great when he recovered his speech, which returned quite suddenly. He was in a punt and it was turned over, and he was capsized into the water, which made him shout out. Practically he was mute for more than eight months. He often shouted words in his sleep about trench warfare, so he must have had dreams but forgot them.

Why should these men, whose silent thoughts are perfect, be unable to speak? They comprehend all that is said to them unless they are deaf; but it is quite clear that in these cases their internal language is unaffected, for they are able to express their thoughts and judgments perfectly well by writing, even if they are deaf. The mutism is therefore not due to an intellectual defect, nor is it due to volitional inhibition of language in silent thought.

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Hearing, the primary incitation to vocalisation and speech, is usually unaffected, yet they are unable to speak; they cannot even whisper, cough, whistle, or laugh aloud. Many who are unable to speak voluntarily yet call out in their dreams expressions they have used in trench warfare and battle. Sometimes this is followed by return of speech, but more often not. One man continually shouted out in his sleep, but he did not recover voluntary speech or power of phonation till eight months after admission to the hospital for shell shock. It was thought that his loss of speech might be connected with adenoids, and he was told that if these were removed under an anæsthetic he would certainly be cured, but in spite of the strong suggestion he did not recover his speech. In another case of a severe character the larynx was faradised, but it made no difference; in fact, it did harm, as it increased the emotional condition. The sudden and varied manner in which these mutes recover their power of articulate speech and phonation is indicative of a refractory condition of the voluntary cortical mechanism of phonation. In some cases there is a history of a blow on the chest—*e.g.*, from a sandbag—or of being buried and partially asphyxiated, and it is usual for the loss of speech to occur at the time of the shock. One patient, however, gave a history of difficult speech for two days after the shock; he lost his speech completely only after his vestibular reactions had been tested; while another, who after the same investigation became a deaf mute, recovered his speech upon hearing a man in the hospital say the word “Rose.” He at once sat up and repeated the word, proving, as he said, “I could both speak and hear.” Some of the earlier and more severe cases of shock followed by mutism were unable to expire forcibly enough to cough, to whistle, or to blow out a candle, but the less severe may be able to perform these acts and yet be unable to speak or whisper. The latter cases recover usually more quickly than the former, but sudden recovery may occur even in the severe cases. Thus a private who went to France October, 1914, on August 9th, 1915, was going to pick up a wounded comrade when a shell came and blew the wounded man to pieces, and he knew no more till about half-an-hour later, when he found himself deaf and dumb. There evidently were two factors in the production of the symptoms—the physical and the psychical—and of the two the emotional shock was probably the

greater. This patient was admitted under my care. Some weeks later his fellow soldiers thought he ought to hear and speak, and they adopted energetic measures to make him shout out for help. Two of them leathered him with a slipper and then nearly throttled him. He struggled and shouted "Stop it." Another man dreamt he was falling over a cliff, shouted out, and recovered his speech. Another dreamt he was blown up by a trench mortar and shouted for help. Finding himself speaking, he continued to speak aloud, and did not go to sleep again for fear he might lose his speech. Another man, a deaf mute, was heard to speak in his sleep. He was told by a comrade. He said, "I don't believe it." Some have suddenly recovered their speech by crying out when unexpectedly feeling physical or mental pain; for example, one man cried out when some boiling tea was spilt over him, another when he was held down and his feet tickled. In most cases it is the sudden and unexpected which restores the function of the vocal mechanism. Thus a mute sergeant saw some soldiers larking in a punt and he suddenly shouted out, "You will be over." Occasionally the stimulus of a well-known chorus has broken down the refractory condition in the psychic mechanism of the voice, and the mute has surprised himself and others by finding himself singing. The recovery of speech may in some cases be only whispered speech—that is, aphonia supervenes. In other cases mutism is followed by stammering or stuttering. Such cases are often found on inquiry to have stammered, stuttered, or suffered with a hesitant speech at some time in their life prior to the shock. In a few cases such a speech defect seems to have definitely originated as a result of the shock. This mutism is due to emotional shock; it is a psychic rather than physical trauma in my judgment, for it in no way differs from the description of hysterical mutism thus given by Bastian: Some of the leading peculiarities of hysterical mutism are these. Its onset is very sudden, and often after a fright or some strong emotional disturbance. Sometimes it follows an hysterical seizure, either with or without paralysis of limbs. At other times it occurs without assignable cause, or it may be induced, as already stated, in some hypnotised persons by suggestion. The subjects of this disability are completely mute, presenting in this latter respect a notable contrast to ordinary aphasia, who so frequently make use of recurring utterances or articulate sounds of some kind. The intellect seems unimpaired, and they were able freely to express

their thoughts by writing. Though the common movements of the lips, tongue, and palate are preserved, these parts (constituting the oral mechanism) are unable to act in the particular combinations needful for speech movements, in association with the other combinations of muscular action pertaining to the vocal mechanism.

Bastian\* notes also that there may be more or less complete anæsthesia of the pharynx in hysterical mutism; this I have observed in some of the mutes. He notes that, as in these soldier mutes, hysterics may recover their speech suddenly as a result of a strong emotion, also as in the soldiers, recovery may be followed by stammering or stuttering.

Bastian refers to a case in which frequently recurring attacks of mutism were generally associated with blindness or deafness, one or both. These conditions are also observed associated with mutism in soldiers, the subjects of shell shock. He also cites a case of his own: a sailor who suffered with a great number of attacks of mutism (the first occurring as a result of fright) who previously had not suffered from any nervous disease and previously had led an active life in all parts of the world. We may therefore conclude that this mutism resulting after shell shock in no way differs from hysterical mutism. It appears, therefore, that there is nothing new in these functional disturbances and disabilities of speech and special senses except it be their severity and frequency in men the subject of shell shock.

#### PATHOGENESIS OF MUTISM.

We may now inquire into the pathogenesis of mutism. Charcot attempted to draw a distinction between aphonia and mutism. He adopted the doctrine of Marey and other physiologists that the larynx takes no part in whispered sounds. According to Charcot, therefore, aphonia (in which the power of whispering is preserved) is a result of a partial paralysis of the adductor muscles of the larynx; while as to hysterical mutism Charcot writes: "If the individual suffering from the affection is unable to whisper, it is not because he is aphonic, or rather because his vocal cords do not vibrate; it is not because he has lost the common movements of tongue and lips—you have seen that this patient was able to blow and whistle; it is because he lacks the ability to execute the proper

\* Bastian, "On Aphasia and Other Speech Defects," p. 126.

specialised movements necessary for the articulation of words. In other terms he is deprived of the motor representations necessary for the calling into play of articulate speech." Charcot therefore believes the oral division of the speech mechanism only to be at fault in hysterical mutism. Wyllie maintains that, whilst this may be so in some cases, in a second group it is the laryngeal division of the speech mechanism which is at fault, and in a third set of cases both oral and laryngeal mechanisms are simultaneously disabled. Bastian alludes to a remarkable case recorded by Guido Banti in which the individual lost his speech owing to a lesion of Broca's convolution, but was able to write, and the general intelligence was not interfered with. Charcot considered hysterical mutism to be an instance of pure "motor aphasia" resulting from a functional trouble in Broca's region. Bastian, however, agrees with Wyllie that aphonia and mutism are most intimately related, differing in degrees only, "and the oral and vocal speech mechanisms are concerned in all speech mechanisms whether sonorous or whispered." Bastian considers that the clinical differences between simple aphasia and hysterical mutism force us to believe in the existence of a bilateral cortical disability in the third inferior frontal convolution.

Sir Charles Bell in his great work on the Expression of the Emotions first drew attention to the influence which powerful emotions exercise upon the respiration. A part of the cortex controls the mechanism of breathing in the production of all voluntary audible sounds, and this, like the movements of the vocal cords, is represented in both halves of the brain, for the muscles of the two sides of the body which control the breath and phonation always act synergically and never work independently. In the oral division of speech mechanism the muscles of one side never act independently of the other. Bastian is probably, therefore, correct in asserting that it is a functional disability of cortical structures in both hemispheres. Whether he is right in asserting that it may be localised in the third inferior frontal is another matter. I believe this mutism is due to functional paralysis of the voluntary cortical nervous centres which control phonation, for many cases cannot produce any audible sound, for they are not only unable to talk or whisper, but to whistle, to utter a cry or to laugh aloud. I examined one case by means of X-rays and found the diaphragm could by no effort of the will be made to descend in a way sufficient to so fill the lungs as to produce an adequate expiratory blast for coughing. He

acquired this power later and was able to take a fairly deep inspiration, but he could not talk, whisper, or whistle; even instinctive audible sounds such as a cough, a cry, or a sonorous laugh he was unable to produce; the voluntary synergic mechanism of phonation was dissociated or inhibited; the failure was in the cortex, for this mute, like many others, talked and uttered cries in his sleep. The return of tone in the voluntary cough is usually a herald of the return of speech.

But why should the mute be able to express his thoughts in writing but not by verbal speech? Writing, like articulate speech, is acquired by imitation; they are part of the social heritage of mankind; the only human heritage connected with this acquired language is the employment of the left hemisphere by the great majority of human beings as the active partner in controlling the lower motor centres of articulate and graphic expression of internal language, upon which thought, reason, and intelligence depend. But an individual who heard no articulate language would speak no articulate language; still, he could express all the primitive emotions and passions by gesture, expression of eye and face, accompanied by modulated audible sounds. This primitive language is universal and understood by all mankind. It is the foundation upon which articulate language rests for expressing the emotions and passions. Without modulation of the voice articulate language expresses no more feeling than graphic language. Now the images required for the production of the voluntary impulses necessary for articulate speech by habit are initiated primarily in the auditory and glosso-kinæsthetic centres of the left hemisphere, but the mental images of audible sounds by which the voice is modulated to express the emotions are initiated in an inborn pre-organised mechanism in both hemispheres (see figure).

In support of this may be mentioned the fact noted by Galton in his 'History of Twins,' that whereas identical twins seldom showed similarity of character in handwriting, the vocal intonation was usually similar. Again, it is true, as Lucretius observes in 'De Rerum Naturæ,' that not only the features but the voice and hair of forefathers are repeated.

Without the mechanism of phonation audible articulate speech, even whispering, is impossible. Two grades of speech defects may be observed in hysteria and as a result of emotional shock—viz., aphonia, in which phonation is extremely weak, and mutism, which

is a complete loss of the power of phonation. Many mutes first recover the power of whispering. Moreover, experiments on the higher apes show that stimulation of the laryngeal centre produces bilateral movements; there is then bilateral representation of the abductors and adductors of the vocal cords. Likewise there is bilateral representation of the muscles which control the breath in phonation. (See figure.)

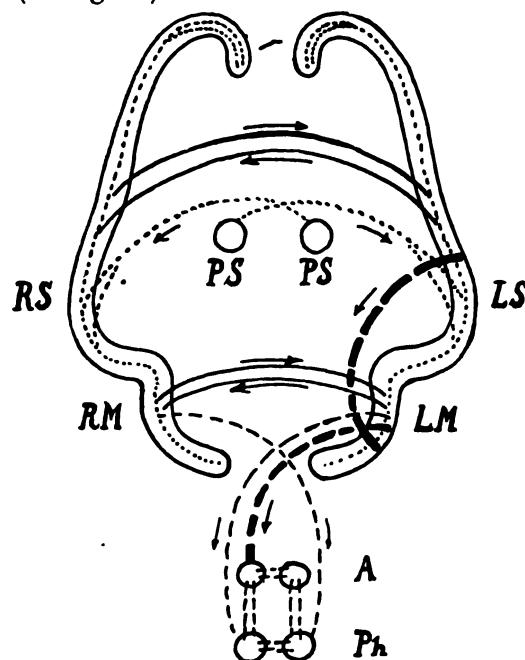


Diagram to Illustrate the Two-fold Mechanism of Articulate Speech.

A represents the lower articulator nervous mechanism; Ph, the lower phonator nervous mechanism; LM, the left motor higher centre of articulation; RM, the right motor higher centre of articulation; LS, the left sensory higher centre of articulation; RS, the right sensory higher centre of articulation; the cortical centres of the speech zone in the two hemispheres are connected by fibres of the corpus callosum indicated by arrows; PS, peripheral auditory nervous mechanism connected with the auditory centre of each hemisphere though mainly with the opposite. It will be observed that the thick interrupted line indicates the *acquired* path of voluntary control over the articulator mechanism in right-handed persons. If this is damaged in early life the right hemisphere becomes the active partner in the production of articulate speech. We are quite conscious of all the movements of the muscles of the tongue, the lips, the jaw, and the soft palate, by which the escape of the breath is modified so as to produce articulate sounds and language. We are conscious only of the pitch and in a measure of the loudness of the voice by the sense of hearing. The production of audible sounds varying in pitch and loudness expresses the emotions; they are voluntarily initiated in both hemispheres and control equally both lower centres of phonation, laryngeal and respiratory.

Consequently we must suppose that mutism is caused by fear producing an emotional shock depressing the activities of the whole of the cortical structures connected with phonation and production of audible sounds.

But we know by the terrifying dreams from which these soldiers suffer that this fear is contemplative and by imagination is continually operating consciously and unconsciously. This terror keeps up its effects, and a refractory phase is induced thereby in the cortical structures controlling voluntary phonation. We speak of being paralysed by fear, and just as *fixed idea* of paralysis of a limb maintains the paralysis by inhibiting volition, so fear is suddenly followed by a loss of phonation, and a paralysis of phonation is established by conscious and subconscious revival of the terrifying scenes in the mind, so that a *fixed idea* is induced thereby in the cortical structures controlling voluntary phonation. We speak of being paralysed by fear, the tongue clave to the roof of his mouth. If fear is continuous, maintained by the imagination, consciously and subconsciously revived in the mind, a *fixed idea* of paralysis of phonation is established in conjunction, perchance, with physical manifestations of fear commonly met with in inutes. But attention becomes centred consciously and subconsciously on this "fixed idea"; a vicious circle is established, and the refractory state in the cortical mechanism of phonation, we have seen, is broken down by a sudden emotional disturbance, in many cases trivial, but attended with surprise taking attention off its guard.

I have hitherto dealt with some of the more important effects upon the mind produced by shell shock, but I will now consider briefly some of the other symptoms complained of, and among the most constant is headache.

#### HEADACHE.

So long as the patient is in a state of shock he feels heavy and dazed and does not suffer great pain as a rule, but later, as consciousness becomes less clouded, so the headache which invariably follows shell shock becomes more acute.

The commonest situation for the maximum pain is the occipital region and the back of the neck; it is often described as a tight compression like a helmet—the helmet of Minerva. The pain may be in the frontal region over one or both eyes, over the vertex, in one or both temples, or at the back of the eyes. The pain is variously described as burning, stabbing, or a heavy dull dizzy feeling, a feeling like a tight hat, or a red-hot wire being run through the temples. It is worse at night, especially upon lying down and trying to sleep. It seems to be correlated with thoughts



of terrifying scenes and is increased when the mind dwells upon these, and it is increased by the mind trying to thrust them aside. The headache has in a few cases increased when the mute man tries to speak, or the deaf to listen, in fact any condition in which the mind is trying to concentrate attention. A few cases have complained of a severe headache for some hours after the recovery of speech or hearing.

#### CARDIAC AND VASO-MOTOR DISTURBANCES.

The patients often complain of palpitation, breathlessness on exertion, and præcordial pain. There may be physical signs of dilatation and tachycardia. The pulse is often small and increased in frequency; the blood-pressure is never high. It was often below 110 and never above 135. The hands are frequently blue or mottled and cold, and often there is cold, clammy sweat of the palms. The surface temperature may be very low; in one case it was only 16° C. The temperature of the hands varied considerably according to the temperature of the room.

#### SENSORY DISTURBANCES.

Cutaneous and deep sensibility of the body may be affected, and in severe cases of shock I have occasionally found loss of skin sensibility to all forms of stimulus, pricking, heat and cold, and touch, also of deep sensibility, pressure of muscles, movement of joints, and bone sensibility to vibration of tuning-fork. The extent and degree of loss of sensibility are variable, and even in one case where the absence of response to stimulus was most marked the limits varied and were not well defined above. The loss of sensibility in this case, however, was pronounced to all forms of stimulus in the lower extremities, although occasionally, after much delay and strong stimulation, a response was obtained in the upper portions of the lower limbs. Even eight months after admission there was a stocking anæsthesia in this case (*vide* pp. 52-54). Hyperæsthesia is even more common than anæsthesia, and even the lightest touch gives rise to apprehension and movements of withdrawal in severe cases.

#### HEARING AND VISION.

Hearing, like speech, and often with speech, is completely lost, so that there is a condition of functional deaf-mutism. Sometimes

speech returns before hearing, or the converse may happen. It is not at all infrequent for a man to be deaf on one side and not the other, and the history often shows in these cases that a shell has burst on this side of the man; the tympanum may be ruptured or the drum is "damped off" by wax forcibly driven against it. Auditory hallucinations are not uncommon, and the patients complain of hearing the bursting of shells, of the noise of shells coming, of bullets whizzing, and of whistles blowing. Many complain of a drumming noise in the ears, especially when they suffer with headache, but this may be replaced by clicking or ticking. Hyperacusis, or extreme sensibility to sound, is a common and very troublesome symptom, making the patient miserable and apprehensive; it also excites or aggravates headache. I found that many relapses occurred during the Zeppelin raid, and one man, a sergeant who had been a professional pugilist of great renown, suffered extremely, so that the noise of the click of billiard balls irritated him to such a degree that he would protest forcibly against the game continuing. His fellow patients found that they could easily cause him to flee by taking their slippers off and banging them on the ground sufficient to produce a sharp loud noise. This case was remarkable in another way; since he had been terrified by the exploding bombs dropped by the Zeppelin he had developed a curious tic, which took the form of jerky purposive movements of the shoulders and head, as if to avoid a blow, and facial grimaces such as a pugilist might assume in a fight.

*Vision.*—The sight may be greatly affected during the acute stage, but it is commoner for the patient to complain of "smoky vision." Again, failure of accommodation and sluggish light reflex are not uncommon in the acute stages. It may in some cases be weeks before the patient is able to read large print. Occasionally there is diminution of the visual fields. Photophobia was met with in some cases, but usually this was due to the irritation of "gas," or occasionally as the result of inflammation due to particles of earth or metal in the eyes; this photophobia was often associated with blepharospasm, often very persistent.

A few cases of functional blindness have been admitted, but these cases more often are sent to special hospitals. One case was of interest. A shell burst near a man while he was attending to a wounded comrade. He managed to drag the wounded man into a culvert, but then found he was quite unable to see. Another

wounded man came into the culvert and helped him to get out. The emotional shock and the darkness of the culvert it appears were responsible for the loss of function.

*Hyperæsthesia* is a very common symptom. I have at present a severe case of great interest under my care.

A man was sent down from the clearing station on February 10th, 1916; he had been blown up and buried; he was blind, deaf, and mute. He was sent from the St. John Ambulance Hospital, France, to the 4th London, and admitted on February 29th. When I saw him he was lying in bed on his side, with his legs curled up. He took no notice of any sounds however loud, he did not speak, and he could not see. This was the condition noted when in hospital in France. When I examined him he could be made to open his eyes, and it was found that the pupils reacted to light; he took no notice of a strong light, nor did he reflexly close the eyes when a blow was suddenly aimed at the face. The slightest touch on the face, however, aroused an immediate defensive movement or withdrawal of the part. It was difficult to test the reflexes, but I failed to obtain any deep reflexes of the lower extremity, and I could not obtain a plantar response. I saw him fed with milk; at first he resented the nozzle of the feeder touching his lips, but as soon as the milk entered his mouth he swallowed it. I understand there has been no difficulty in feeding him. He responds to the calls of nature, and does not wet the bed. He is even more sensitive and apprehensive to touch than the deaf-mute, who also showed fear of being injured when touched. The next day while suffering from the pain of an enema, which was relieving the bowels, he somewhat suddenly regained his sight. He looked around in a bewildered manner, then burst into tears. The next day he was able to write. His powers of recognition were good, but he had a complete gap in his memory of the whole time he was in France. With the recovery of sight the skin hyperæsthesia disappeared. There was still a bewildered blank expression of the countenance, but he was able to tell us where his home was, how many brothers and sisters he had, their names and ages, as well as other information except his experiences in France. Two days later he had a sort of hysterical fit and recovered his speech and hearing. The next day I saw him he greeted me with a happy expression of the face, and I congratulated him upon his recovery. He was able to converse upon most subjects, but there was still a

complete loss of power of recollection of all that had happened in France.

This blind deaf-mute, then, was for a time conscious of the external world only by tactile and kinæsthetic perceptual impressions, consequently the mind was focussed on them in his life of external relation. Owing to the effect of past terrifying experiences constantly revived in dreams and very possibly, being blind, by hallucinations, his mind was constantly suffused with fear and apprehension of danger, hence the protective reactions of withdrawal of a part touched were greatly exaggerated.

*"Severe shell shock." Functional deaf-mutism following Barany experiment; "terrifying dreams"; pantomime of bayoneting in sleep; sudden recovery of hearing and speech, with severe mental disturbance.*

A deaf-mute was admitted under my care; he displayed extreme apprehension of being touched in any part of his body. Although quite unable to hear any sound or produce any audible sound, he was able to write a lucid account of his experiences. He told me that he was at Gallipoli, and that while in the trenches a big shell fired by one of our monitors fell short into the trench he was in, and he lost consciousness. When he came to he was neither deaf nor speechless, but in the Canadian hospital the doctors had syringed his ears with hot and cold water, and that he became deaf and dumb. This man had terrifying dreams of trench warfare; he had had a slight wound of the right arm, which he continually felt, and he was most apprehensive of being touched on it or any part of his body. Captain Brown, at my request, hypnotised him, but it did not restore his hearing and speech. I suggested that his speech would come back to him on a certain day, and, although this did not happen, yet he began to whisper the vowel sounds and whisper words of one syllable. I assured him it would come back, and every day he greeted me with the thumbs up. During the several months this man has been in the hospital, he has on many occasions been observed to sit up in bed, look under the bed, first on one side then on the other, then perform the pantomime of bayoneting the enemy. Of this he has no recollection. On March 10th he had a kind of hysterical fit, and Dr. Ash, in the absence of Captain Brown, was summoned. A little later it was found that he could both hear and speak. I saw him the next day; he greeted me with a joyful face and thanked

me. Curiously, he had lost his recollection of having written down that he had lost his speech after the treatment in the hospital, and he said he remembered nothing about the incident, although he told us again that the monitor had dropped a shell in the trench that he was in. All the hyperæsthesia had now disappeared; he no longer instinctively shrank away from being touched.

It is remarkable to note that these two cases illustrate in an extreme degree, in the form of an hysterical fit, the mental shock that often precedes or accompanies the restoration of the functions of hearing and speech. When this does not happen it is not uncommon to find the patient complaining of headache or dizziness following or preceding the restoration of function.

#### TREMORS.

Tremors are extremely common and constitute a serious disability; they are coarse and fine, continuous during the waking state, absent in sleep; they may be general, affecting arms, legs, and head; they may affect one half of the body, both lower limbs or both upper limbs. They are most often rhythmical coarse tremors, very like those of paralysis agitans; sometimes they are increased by intention so as to resemble disseminated sclerosis; sometimes they are fine tremors like those of exophthalmic goitre. A true functional tremor as distinguished from the malingerer's tremor is usually not altered in its rhythm by taking the individual's attention away—*e.g.*, by making him count slowly and quickly.

The following was a remarkable case of functional tremor completely cured by strong suggestion :—

Gunner —, aged 39, 15 years' service, R.F.A., 49 B. Out in France 10 months. Admitted to the 4th London in January, 1916. Last August, between Ypres and Flamentières, about 3 o'clock in the morning a big shell exploded near him and he remembered no more until he found himself, 14 days later, in the military hospital, Chatham. The colonel told him he was lucky to be there at all. He believes the shell killed a number of his comrades. He was afterwards transferred to Colchester. When I examined him he was sitting in a chair; legs, hands, and jaw were in continuous coarse rhythmical tremors like those of paralysis agitans, which

became exaggerated when he was spoken to. Every now and again he starts and looks upwards and laterally as if he feared a shell would drop on him; his hearing is extremely acute, and the firing of the guns at Woolwich causes him alarm. In narrating his history there is a constant repetition of words. He dreams of shells bursting, and a fellow patient says he has disturbed sleep, groans, and utters moans and sounds, and wakes up with a start at the least noise. It is very difficult to test the reflexes on account of the continuous tremor. The face is flushed, the palms sweating, but the surface temperature is not lower than normal. The pulse is good. *Sensibility and special senses*: He does not respond to the prick of a needle on the lower limbs or left arm and hand; but after delay responds immediately on the right hand. Pricking of the face causes immediate response. He does not feel the vibration of the tuning-fork on the feet, legs, or hands, but does on the forehead, and there was a marked contrast between the bone sensibility of these parts. He hears the fork quite well at 6 inches from the ears. He has some difficulty in recognising colours: he picked up the blue box, but was a long time before he picked up the red. His sense of weight was not abolished, but it was difficult to test because of the tremor, which became of much greater amplitude, resembling in fact the intentional tremor of disseminated sclerosis, and caused the pennies to rattle in the boxes. It is possible that his judgment of the relative weights was aided by hearing the pennies rattle. He could taste very bitter fluids, but could not recognise vinegar, salt, or sapid fluids. The sense of smell was considerably affected, for he did not recognise tincture of assafoetida, otto of roses, and oil of cloves; he smelt nitrite of amyl and recognised strong ammonia and glacial acetic acid, but they seemed to have much less stimulating effect than might have been expected. Having made a most careful examination I said to this patient, "I am sure there is no organic disease, and you will get perfectly well and lose these tremors in a few days," which he did. I employed him for a short time as an object lesson to other new cases with tremors. He is at a convalescent home now, a happy being.

Various tics have been observed which, however, may be found by inquiry to have existed prior to war experiences and been merely exaggerated by shock. Torticollis, facial tics, and blepharospasms have been observed. Choreiform movements have been

noted, and often these are due to unconscious imitation of other patients affected.

#### FUNCTIONAL PARALYSES—GAIT.

Functional paralyses are not at all uncommon, the most common being paraplegia, but hemiplegia and monoplegia are also frequently met with. A history shows that suggestion of injury plays a very important part in causing and maintaining a fixed idea of paralysis. Thus a man is blown up and falls on his shoulder; although the injury is not sufficient to prevent him moving his arm, the limb becomes paralysed. In several a simple bruise of the hip led to functional paralysis of the leg, or falling on one side of the body that side becomes hemiplegic and remains so unless the *fixed idea* is abolished. Paraplegia frequently arises from an injury of the back. In these cases of functional paraplegia either the plantar reflex is flexor or no reflex response is obtained; the knee-jerks are exaggerated and an ankle clonus may be obtained, but it is not a true rhythmical clonus. The sphincters are not affected and the deep sensibility is usually unaffected; thus, they say, they feel the vibration of the tuning-fork.

There are many different *gaits*. There is a refusal to attempt to walk. There is a dancing tremor as if the legs were springs of coiled wire. Owing to the fear of raising the foot from the ground the patient shuffles the feet along the ground on a wide base, making only small progressive advances. The patient may drag both soles of the feet along the ground one after the other. Another gait is that assumed by the patient who thinks he can only walk by means of supports afforded by two sticks. He thus comes to assume a persistent leaning forward posture even when at rest. Two such cases have recently been admitted under my care almost bent double through being allowed to think they could not walk without the aid of forward supports, making them into quadrupeds. Having assured myself these were functional cases, I said, "Take away those sticks: I want to see which of you two will first be erect again." In a week they were almost well. Likewise with a hemiplegic who for 13 weeks had thought he was paralysed and had been given crutches I said, "Take away those crutches." In a few days the fixed idea of hemiplegia was entirely abolished, and in a week, from a paralysed miserable being, he was a cheerful healthy man.

I am instituting a museum of crutches, sticks, and other supports

of patients admitted from hospitals where they have been many weeks and months, only waiting to be assured that there was nothing the matter with them.

#### THE ATMOSPHERE OF CURE.

Be cheerful and look cheerful is the note that should ever be sounded to these functional cases. Sympathy should not be misplaced, although it should be shown to all these poor fellows who have a fixed idea of never recovering: it is not their fault, it is a real thing to them, and no one could be more grateful than these cases of functional nervous disability for cheery words. I use many of these cases that have recovered as object-lessons. I do not find hypnosis or psychanalysis necessary or even desirable; only common-sense and interest in the comfort, welfare, and amusement of these neurotic patients are necessary for their recovery. The conditions at the Maudsley Hospital will be all that can be desired. There are light airy wards, and day rooms for meals and recreation, plenty of single rooms for the isolation of cases that are troubled with noises or require special attention; and especially valuable are the baths, so that every soldier can get a warm or cold spray bath every day. The warm baths, and especially the continuous warm baths, of which there are eight, are especially valuable for promoting the action of the skin, of relaxing the tired muscles, and by the soothing influence helping to induce sleep, so that less hypnotics are required to be employed.

Diversion of the mind from the recollection of their terrifying experiences is essential for successful treatment. This can be best accomplished by the provision of every form of healthy indoor and outdoor amusements—*e.g.*, books, games, and music. These are better in a recreation hall where convalescent patients can enjoy themselves. I have alluded to the hypersensibility of many of these patients to sounds, consequently neither gramophones nor billiards should be within the hearing of these acute cases. The out-patients' waiting-room will be utilised at the Maudsley Hospital for recreation. A full-sized billiard table with all accessories has been anonymously presented to me by a lady, and I hope others of the charitable public interested in the welfare of these poor fellows suffering with shell shock will help to provide healthy amusements and games so essential to successful treatment.



Mr. President and Gentlemen, I began these lectures by stating that a new epoch in the history of war had arisen in consequence of the terrible new experiences resulting from the use of high explosives. Some of you may have read "Aunt Sarah and the War," and remember the following passage from a letter of Captain Tudor, in which he draws a comparison between insignificant home troubles and the experiences at the front. "Lord, if they could listen to the unceasing shells that drive some men deaf, some men blind, some men dumb, and other men crazy, and these all of them MEN, with a newly earned meaning in the word; for there's a new meaning now in many an old word. We shall want a brand new Dictionary, and its deuced hard on good old Murray, that just at the end of his great work he should need to begin it over again."

Sir DAVID FERRIER said: I rise to propose a cordial vote of thanks to Dr. Mott for his admirable lectures, which I am sure we have all, without exception, listened to with much pleasure and profit. Dr. Mott has chosen a subject which is of great interest to us all at this time, and no one is better qualified than he to deal with it, considering his eminence as a neuropathologist, and his special experience as physician to one of the largest military hospitals for cases of this kind.

The effects of shell explosions on the human body are of the most diverse character, and here and elsewhere others have discussed them as affecting different regions and organs. Naturally Dr. Mott, as a neuropathologist, has confined himself to a consideration of their effects on the central nervous system. Even here, however, as he has shown us, they are apt to be more complex than they might at first sight seem, for, in addition to being functional or organic or both, they may also be toxic owing to the gases given off by the partial or complete combustion of the explosives. He has illustrated these effects by many beautiful and convincing diagrams.

It is naturally difficult in any given case to disentangle the various factors at work and to assign each its proper place. Probably cases occur in which all of them have been more or less operative.

Touching the effects of shell explosions which cause organic damage to the nerve centres without any external appearance of mechanical injury, the most probable explanation, as given by Dr. Mott, is that they have been caused by concussion against or a blow with some yielding heavy substance like a sand-bag, which would not leave any obvious mark.

It is a question whether, apart from this, the terrific condensation of the air caused by a high explosive can of itself cause organic damage to the body.

Dr. Mott, I understand, favours this view, and there are many facts which support it. For we know that the explosion of a cake of dynamite will obliterate the lumen of a gun or cut through a steel bar on which it is placed.

As to the effects on the nervous system of shell explosions which do not cause any obvious organic damage, and to which alone the term "shell shock" is strictly applicable, Dr. Mott has described these in full

and graphic detail, in this his last lecture. They do not seem to differ in essentials from those of the so-called traumatic neuroses with which we are all familiar under other conditions of intense emotional shock, such as railway accidents, and the like.

They are perhaps more intense, and they are specially coloured by the circumstances in which they occur, as exemplified by the character of the dreams and hallucinations. In the majority, as in traumatic neuroses in general, there is the neuropathic constitution or inheritance, which constitutes the—as it were in legal phrase—"contributory negligence" on the part of the patient.

But I can well believe that, apart from this, even the strongest natures may break down under the terrible ordeal which they have to undergo.

All these points, and many others which I cannot specify in detail, have been discussed by Dr. Mott in a masterly manner, and I think that the Society is to be congratulated that the Lettsomian Lectures of the year have been maintained at such a high standard of excellence.

Sir JAMES KINGSTON FOWLER, in seconding the vote of thanks, said that he had listened to many Lettsomian Lectures, but to none which had interested him so much as those of Major Mott.

The lecturer had explained the pathological changes responsible for the remarkable clinical phenomena associated with shell shock, and the knowledge of the nature of these changes would be of great assistance to those who, like himself, had many such cases constantly under their care.

Many cases illustrating the conditions which Major Mott had so ably described had been under treatment at the 3rd London General Hospital.

In the treatment of the various forms of functional paralysis following shell shock he had been associated with Captain Wilfred Harris, who, by the use of faradism and suggestion, had in many cases of paralysis of long duration effected cures which would in ancient times have been regarded as bordering on the realm of miracle.

It was first proved to the patient that he could feel, next that under electrical stimulation his limbs were capable of movement, then that under the influence of his will he could himself move his limbs.

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## PUNCTIFORM HÆMORRHAGES OF THE BRAIN IN GAS POISONING.

By F. W. MOTT, M.D., LL.D., F.R.S., Major R.A.M.C.(T.).

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THE subject of punctiform hæmorrhages in the brain in gas poisoning has awakened new interest on account of its existence in fatal cases of shell shock with burial, and in cases of death from inhalation of poisonous gases, either as a result of their liberation by explosives in confined spaces, such as mines, trenches, and dug-outs, or as a result of an offensive gas attack by the enemy. I shall endeavour in this communication to explain the cause of these punctiform hæmorrhages.

In 1907 I published in the *Archives of Neurology and Psychiatry* (iii) a paper on "Carbon Monoxide and Nickel Carbonyl Poisoning." I came to the conclusion that the nickel carbonyl poisoning was really due to the inhalation of CO employed in the manufacture of nickel. Two such cases occurred of which I had the opportunity of examining the central nervous system, and I found multiple punctate hæmorrhages throughout the white matter of the brain, as you see in these photomicrographs.

In this paper I compared the naked-eye and microscopic appearance of the central nervous system in these cases of nickel carbonyl poisoning, with those observed in a case of suicide by illuminating gas, and I

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considered them to be identical in nature. I also reviewed in this paper the clinical symptoms and pathology of CO poisoning, in respect to the findings in the central nervous system, and especially the causes which occasioned the hæmorrhages. All three cases died in from four to eight days with the complication of pneumonia. Thrombotic occlusion of the cerebral arterioles or venules was considered to be the cause of the hæmorrhages; in one case from the nickel carbonyl works an organized thrombus was found in a vessel of the medulla.

In the case of suicide by illuminating gas, admitted under my care at Charing Cross Hospital, signs of cerebral hæmorrhage occurred within twenty hours of commencement of the inhalation of the gas, for the limbs became rigid, and a plantar extensor reflex was obtained. At first the temperature on admission was 99° F., but when the rigidity of the limbs and the plantar extensor response was discovered six hours later, the temperature had risen to 105° F., and the pulse and respiration had become very rapid.

The nervous symptoms pointed to the occurrence of the punctiform hæmorrhages found post mortem in the internal capsules, and it may be assumed that the rise of temperature might have been due to the toxæmia coincident with the onset of pneumonia; for when the patient died, on the fourth day, pneumonic consolidation was found. Full notes of the clinical symptoms and post-mortem findings were reported. Microscopic investigation showed fatty degeneration of the heart and of the epithelium of the convoluted tubules of the kidney. Punctiform hæmorrhages, attributed to hyaline thrombosis of small vessels of the white matter, have been described by Bignami and Nazari in various diseases; for example, æstivo-autumnal malaria, apoplexy, diplococcal meningitis, following pneumonia and measles. It is possible, therefore, that pneumococcic toxæmia was productive of, or associated with, the causation of the hæmorrhages in these cases of CO poisoning.

But I am inclined to think that the CO poisoning alone would be capable of causing the punctiform hæmorrhages, for the following reasons: In both cases from the nickel works there was evidence of old hæmorrhages in the form of minute round or oval punctiform patches of softening, indicative of gas poisoning on some occasion previous to the man being obliged to give up work. And it was legitimate to attribute these symptoms they suffered with—namely, giddiness, vomiting, and

headache (migrainous attacks)—to the gas poisoning, causing congestive stasis and hæmorrhages. It is well to note that these migrainous attacks are frequently met with in men and officers who have been exposed to those conditions in which CO or other forms of gas poisoning might have occurred without fatal results.

From the facts observed in these three cases of CO poisoning, combined with certain anatomical conditions of the blood-vessels supplying the white matter of the brain, to which I shall now direct your attention, an explanation can be offered why these miliary hæmorrhages are found in the white matter of the cerebrum and basal ganglia, and not elsewhere in the brain. It must be recognized that a combination of factors may arise in CO poisoning—namely :—

(1) The heart, owing to the anoxæmia, has to beat faster, and to do more work with less oxygen; consequently it may undergo fatty degeneration.

(2) There is microscopic evidence of an irritative and degenerative endothelial change in the cerebral capillaries, as shown by mitosis of the nuclei, and a fatty degeneration made apparent by osmic acid staining. These changes may be due, as Lancereaux suggested, to CO in the serum, but aggravated by the pneumococcal toxin, which is also responsible for a tendency to increased fibrin formation of the blood, and to thrombosis in those vessels in which the anatomical conditions favour the lodgement of emboli, or clotting of the blood from congestive or inflammatory stasis.

The microscopic appearances of these punctiform hæmorrhages in known cases of CO poisoning, terminating in death by pneumonia, are similar to those shown in fig. 1 (p. 7), which is a section of the corpus callosum, showing punctiform hæmorrhages, from a case of shell shock with probable CO poisoning.

#### MILIARY HÆMORRHAGES IN CASES OF SHELL CONCUSSION AND GAS POISONING.

I may now mention that the microscopic appearances found in these cases of CO poisoning, dying with pneumonia respectively after four days, eight days, and seven days, were in all respects similar to the appearances presented by sections of brains received from France, notified as dying of shell shock with burial and from gas poisoning—with one exception, and that only differed in the fact that

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a large part of the hæmoglobin had been converted into chocolate-coloured pigment granules, which blocked the small vessels in the hæmorrhages.

Before proceeding to the description of these cases I will call attention to the anatomical relations of the vessels of the white matter of the cerebrum, where these hæmorrhages are found.

##### ANATOMICAL RELATIONS OF THE VESSELS FAVOURING CAPILLARY STASIS.

The pia mater covering the cortex sends delicate walled arteries and veins through the cortex to reach the subjacent white matter; the arteries consist of short and long vessels which, after giving off fine branches to the interlacing capillary network of the grey matter, terminate in a brush of fine arterioles; the short vessels end in this brush just below the cortex; the long penetrate deeper, to end in the corpus callosum and the centrum ovale. Each little artery breaks up into a tree, and forms a separate system of delicate arterioles. Each arteriole ends in a circumscribed area of capillaries, with an emerging vein. These veins do not anastomose. Thrombosis of arterioles or venules would therefore cause capillary stasis and hæmorrhage into the brain substance in a circumscribed area, also escape of blood into the perivascular sheaths of arterioles or venules; a condition generally found to occur where there are punctiform hæmorrhages. Owing to the thin character of the walls of the arteries, it is difficult to decide whether a vessel in section is an artery or a vein. Punctiform hæmorrhages are also found in great abundance in the brain structures supplied by the perforating arteries, especially those in which the opto-striate and lenticulo-striate branches terminate. These vessels give off relatively few branches until they reach their destination in the basal ganglia and internal and external capsules; they then terminate in a brush of delicate walled arterioles. Each vessel supplies, as in the case of the cortical vessels, circumscribed areas of capillaries, and the result of embolism or thrombosis is the causation of similar small limited areas of hæmorrhage and softening, which, when numerous, may become confluent. Stasis is favoured also by the narrow lumen of the capillaries of the brain.

## SHELL SHOCK AND CO POISONING.

The brain of a man said to have died from shell shock was handed to me by Professor Keith for examination. The following notes accompanied this brain:—

Fatal case of shell shock with burial, from Captain Armstrong, R.A.M.C., No. 7 Mobile Laboratory, B.E.F. Sent on from No. 1 Mobile Laboratory. No. 8 on Captain Armstrong's list.

Brain of man, admitted unconscious, with history of having been buried by shell blowing in parapet. Remained stertorous for two days and died.

*Post-mortem Examination.*—There is no wound of any kind on his body or head, and no visceral lesion. His ankle on one side was badly "sprained," but there were no fractures. The skull was unfractured, and no fracture of the base could be found. Brain shows multiple punctiform hæmorrhages and some slight subpial extravasation. No other particulars.

Photomicrographs illustrating the appearances presented by the brain in this case have been already published to illustrate my Lettsomian lectures to the Medical Society (1916).

Having regard to the fact that these punctiform hæmorrhages and hyaline thrombosis of vessels were identical in their microscopic appearances to those I had observed in CO poisoning, it occurred to me that the man may have been concussed and afterwards gassed while lying unconscious and buried (*vide* fig. 1).

It may be argued that these punctiform hæmorrhages were due solely to venous stasis and congestion, but I doubt this, for I have neither observed this condition in the number of cases of death from asphyxia occurring in status epilepticus nor after prolonged seizures of paralytic dementia, although I have examined the brains, macroscopically and microscopically, in a great number of instances.

A letter to me from the Trench War Committee confirmed the possibility of CO poisoning occurring when a large shell burst in a confined space, such as a dug-out or a trench, if incomplete detonation of the explosive occurred. Moreover, it must be remembered that CO is odourless, and may be present in trenches or dug-outs without its existence being known. When a mine is exploded considerable quantities of this gas may be formed, and it may travel through the ground considerable distances.

In the memorandum on "Gas Poisoning in Warfare" issued by the

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Director-General, Medical Services, British Armies in France, it is stated in respect to CO poisoning—

The lungs show no abnormal changes in cases of rapid death. Small punctate hæmorrhages may be found in the white matter of the brain, and sometimes ecchymosis in the meninges, if the case has been exposed to a concentration of CO sufficient to cause prolonged unconsciousness.

The fact that CO is not found in the blood when the patient is examined, does not prove that death was not due to CO poisoning, for after some hours of exposure to air it cannot be detected, and there is little opportunity for making the test for some hours or even days. Captain Dunn read a very interesting paper before the Medical Society on epidemic nephritis, in which he showed hyaline thrombosis of the vessels of the alveoli of the lungs and of the glomerular capillaries of the kidney.

In these cases he has observed multiple punctiform hæmorrhages of the brain, which he attributed to embolism by hyaline thrombi. These hæmorrhages present exactly the same appearances as in CO poisoning or gas poisoning. In a letter he has written to me, he states that he has now observed these hæmorrhages in four more cases of nephritis, so that their occurrence in the first case was not fortuitous. "They are of quite similar appearance to those I have observed in phosgene poisoning." He asks whether hæmorrhages of that type are seen in uræmia. Lieutenant-Colonel T. R. Elliott has forwarded me a memorandum by Captain H. W. Kaye on five autopsies on cases of poisoning by drift gas ( $\text{Cl}_2 + \text{COCl}_2$ ) in which he describes blue-black dots in the brain of a seventy-hour case; he also refers to petechial hæmorrhages in the stomach and evidence of blood destruction in the spleen. Lieutenant-Colonel Elliott also calls attention to the fact that Captain Henry was the first to describe thrombi in the renal vessels and he disagreed with Dunn and McNee when they described renal emboli as coming from the lung.

EXAMINATION OF THE BRAIN IN GAS POISONING.

I have recently had the opportunity of examining the brains of two cases of gas poisoning, in which gas was employed in an offensive by the enemy; and one is of special interest.

The whole of the white matter is peppered over with small dark blue



spots about the size of a pin's head. These are due to hæmorrhages, but microscopic examination shows conditions which I have not found in CO poisoning, nor in other forms of gas poisoning; in fact, I have never seen any condition like this. The red blood corpuscles have been in large measure broken up, and the hæmoglobin converted into dark chocolate-coloured pigment granules, which fill the capillaries, arterioles and venules of the white matter of the brain. This is very possibly

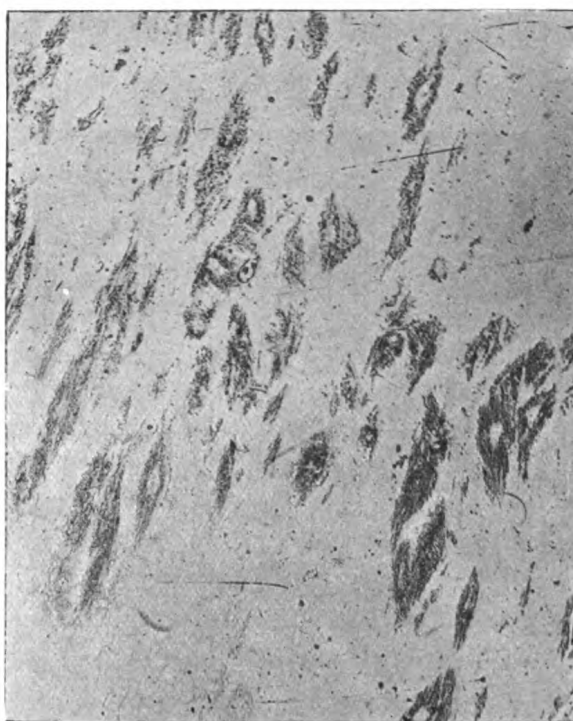


FIG. 1.

Punctate hæmorrhages in corpus callosum from a case of shell shock and burial; very probably accompanied by gas poisoning while lying unconscious and buried. Observe the small white area in the centre of the hæmorrhage, in the middle of which is a small vessel which, under a higher magnification, will be seen to contain a hyaline thrombus. ( $\times 20$ .)

methæmoglobin, for it is known that exposure to nitrous fumes in concentration will oxidize the hæmoglobin, and convert it into methæmoglobin. Phosgene,  $\text{COCl}_2$ , has been used by the Germans;

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it liberates HCl when it comes in contact with a moist surface; it is very irritating and would cause bronchiolitis, and I am informed by my friend Professor Halliburton that it is possible the free hydrochloric acid would convert the hæmoglobin into acid hæmatin.

Similar appearances were found to those described in CO poisoning—namely, multiple punctiform hæmorrhages in the white matter—but the blood corpuscles were intermixed with chocolate-coloured pigment granules (Plate I). The accompanying drawings illustrate the appearances presented. You may observe a vessel with a hyaline thrombus, stained pink by the fuchsin of the Van Gieson stain, but

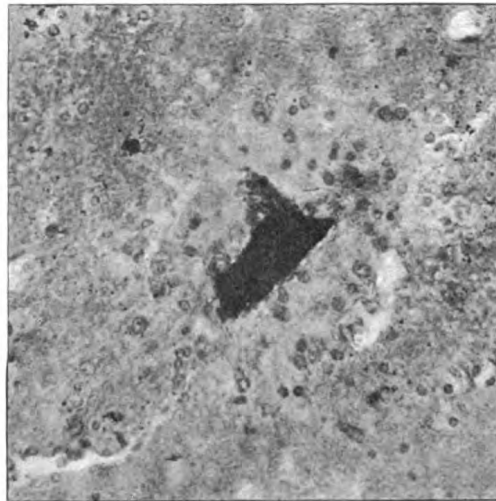


FIG. 2.

Hyaline thrombus of vessel in centre of a punctate hæmorrhage. The thrombus was stained brown by dissolved pigment. Around the blocked vessel is a white area of brain substance containing numbers of leucocytes; outside this is the hæmorrhage, not very distinctly seen. The specimen was prepared from the subcortical white matter of the frontal lobe. ( $\times 345$ .)

with a brownish tinge due to the change in the blood pigment (Plate II).

Possibly, as in capillary fat embolism, we may have embolism by these pigment granules, but, generally speaking, there is definite evidence of thrombus formation, with pigment granules in the thrombus.



PLATE 1.

Section of optic thalamus, showing vessel blocked with pigment going to hæmorrhage; amidst the blood corpuscles are numerous pigment granules. To the left of the larger vessel are three capillaries packed with pigment and compressed together. ( $\times 350$ .)

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PLATE II.

Small vessels blocked with pigment in hæmorrhage, and to the right a larger vessel, probably a vein, filled with lightly brown-stained hyaline thrombus. ( $\times 150$ .)

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Examination with a high-power magnification shows that the smallest vessels are filled with the pigment, which can be seen in the vessels and in the circumscribed areas of hæmorrhage as discrete granules packed together (Plates I and II).

The specimens show hyaline thrombus formation in the vessel contained in the centre of the hæmorrhage or passing to the centre of the hæmorrhage; the walls of these vessels are generally so thin as to support the view that they are veins (fig. 2). Some of the small vessels

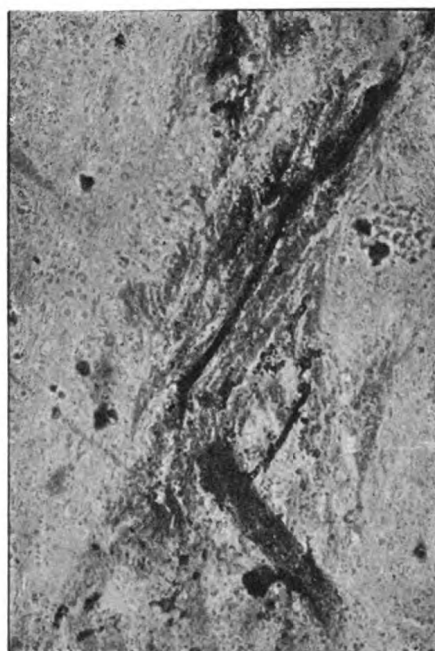


FIG. 3.

Small vessel breaking up into a leash of small arterioles compressed together by the hæmorrhage. The vessels are all blocked with black pigment granules. Specimen from internal capsule gas poisoning. ( $\times 70$ .)

show aneurysmal dilatation. In one section I observed a leash of small arterioles pressed together by the hæmorrhage at the side; on one there was an aneurysm filled with pink-stained thrombus (figs. 3 and 4). Amidst the corpuscles are numbers of pigment granules. Three such hæmorrhages with occluded vessels proceeding to them can be seen (fig. 5, p. 11). Nearly all the punctiform hæmorrhages show a central

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vessel, surrounded by an area of necrosed brain tissue, infiltrated usually with leucocytes (fig. 2, p. 8). The whole of this area is stained pink by Van Gieson's stain, and it is more or less difficult to make out the wall of the central vessel. Sometimes a capillary filled with a thrombus can be seen running to the central vessel. It may be filled with chocolate-coloured pigment granules probably embedded in a coagulum as in Plate I, or the coagulum may be of a pinkish-brown colour due to the



FIG. 4.

Leash of small perforating optostriate arteries filled with pigment granules.  
Two of the arterioles show miliary aneurysms. ( $\times 350$ .)

coagulum being stained by the pigment dissolved in the serum (Plate II). In this, as in all other cases, there is evidence of an inflammatory stasis and excess of leucocytes in the vessels, and often into the perivascular sheath and tissues around.



*Clinical Anatomical Notes accompanying this Case.*

*Brain.*—Surface veins large and small, distended with dark blue clotted blood (veins of base of skull were in same condition). Section shows thickly scattered blue-black dots throughout the brain, especially in the white matter; this applies also to the cerebellum, and to much less extent to the pons and medulla.

No hæmorrhage seen.

Patient was admitted ten hours after being gassed, and died sixty hours after admission, from bronchiolitis and failure of right heart.

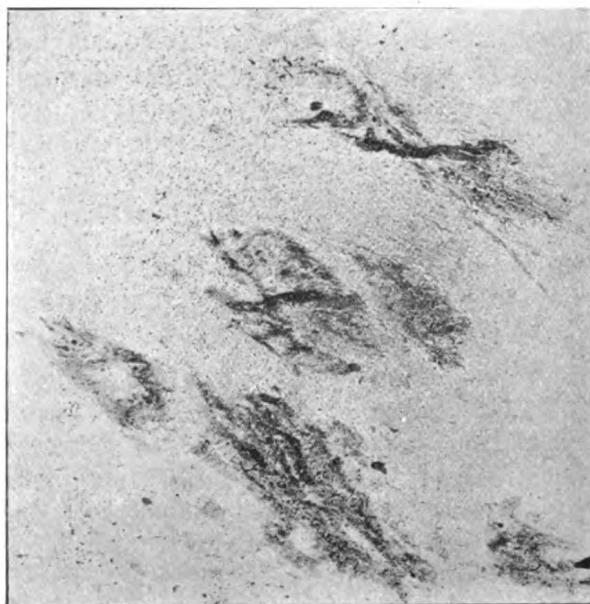


FIG. 5.

Three punctate hæmorrhages showing optostriate arterioles filled with pigment granules. ( $\times 30$ .)

It is unfortunate that the clinical and post-mortem notes of this case are so scanty, for it is one of great pathological interest. The right heart failure and bronchiolitis, from which the patient died seventy hours after inhalation of the gas, would undoubtedly account for the venous congestion and stasis noted post mortem, and for the thrombosis of the small vessels in the white matter of the brain. The blocking

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of the capillaries, small arteries, and veins by the chocolate-coloured granules of pigment, especially of the capillaries, would, however, suffice to account for the hæmorrhages. In some respects the capillary blockage by pigment resembles the condition found in pernicious malaria, in which disease Bignami and Nazari have described punctate hæmorrhage of the white matter of the brain; but I am inclined to believe the principal cause of the hæmorrhages is inflammatory stasis and hyaline thrombosis of arterioles, capillaries, and venules, the pigment granules being incorporated in the coagulum.

I received the brain of another case in which the bruises on the body, the hæmatomata in the right lung, and the other conditions described, all suggest that he had been blown up by a shell and buried, and that the injuries of the brain were due to concussion. The fact that there was no CO detected in the blood does not conclusively prove that he was not exposed, while buried, to CO gas.

*Clinical Notes of this Case.*

Admitted with diagnosis of shell shock. Purple bruises on arm and leg of right side. Stertorous, unconscious, and during the night before death, constant fits. Lived thirty hours in hospital.

*Post Mortem.*—There were two hæmatomata in the right lung, but no other visceral injury. No hæmorrhage of the scalp, and no fractures of the skull. Some slight subpial hæmorrhage of the right hemisphere. Fornix destroyed and full of hæmorrhages; hæmorrhages also seen in corpus callosum. Hæmorrhage in both optic thalami; cerebrospinal fluid tinged with blood. Men admitted with him said he had been buried by a shell. There was no CO in his blood, and the bruising was purple.

*Microscopic Examination.*—Multiple punctate hæmorrhages are seen; hyaline thrombosis of capillaries, arteries, and venules; perivascular sheaths contain blood (Plate III). Marked evidence of inflammatory stasis. Some of the small veins are filled with blood corpuscles, one-half of which are polymorphonuclear leucocytes, and in the perivascular sheath and tissues around are large numbers of polymorph leucocytes.

*W. O. C. 862.*

REPORT ON A CASE OF "SHELL GAS POISONING," ADMITTED INTO  
141 SECUNDERABAD CAVALRY FIELD AMBULANCE ON AUGUST 31,  
1916, WHICH TERMINATED FATALLY ON SEPTEMBER 5, 1916.

No. 1489 S. D. had been one of a working party which was caught in a "gas-shell barrage" put up by the enemy on the morning of August 31, at about 10.30 a.m. The majority of the shells on bursting made a small explosion and formed a quickly dissipated white smoke. At the time he was standing in a trench 3 to 5 ft. deep, and appeared to have been knocked down by the explosion of this particular shell. Whether or not he had on an anti-gas helmet at the time is uncertain, but it appears that after the man next to him was wounded they both removed their anti-gas helmets, and were found lying in the bottom of the trench. He was soon placed on a stretcher and removed to a dressing station. As to whether he received any definite medical treatment prior to his admission into 141 Cavalry Field Ambulance at 7 p.m. is uncertain.

On admission: Patient was unconscious and frothing slightly at the mouth and nostrils. He was distinctly collapsed. There were no signs of cyanosis. (a) Pulse 112, regular, but weak. (b) Respirations 53, deep, no signs of obstruction. (c) Temperature 96° F. Patient was very restless and had a slight cough. There was a small superficial scalp wound behind his right ear, and also a superficial wound with considerable bruising of tissues round about on back of left shoulder.

Physical signs: A few râles could be heard over the front of the chest, but nothing abnormal at the back. There was no evidence of accumulation of fluid.

Treatment: Immediately on admission  $\frac{1}{80}$  gr. strychnine was given hypodermically. Ammonia capsules were administered from time to time. Oxygen was administered (through the mask of a box respirator) for four minutes every quarter of an hour. The oxygen for a time quietened the breathing, and the frothing at the mouth and nose ceased.

10 p.m.: Pulse 120, weak and irregular. Respirations 40, deep, and no obstruction. Temperature 96.4° F. Patient was again given  $\frac{1}{80}$  gr. strychnine.

11 p.m.: Ammonia capsules were ordered to be used continuously. At first there was considerable improvement in the pulse, although the rate remained the same (120), but this improvement was only temporary, and at 11.30 p.m. the pulse again became very feeble and irregular and its rate now was 148.

12 p.m.: No signs of improvement. Patient was unable to swallow.

3.15 a.m.: Patient was losing ground rapidly. The pulse was almost impossible to count. Respiration 60. Temperature 97° F. Patient was very restless.

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Oxygen had been administered continuously for four minutes every quarter of an hour since admission. The administration of same seemed to bring on the restlessness of the patient, and as there was no evidence of cyanosis and no respiratory obstruction the oxygen was stopped.  $\frac{1}{80}$  gr. strychnine was again given.

6 a.m.: Evidence of slight improvement, and patient was able to swallow a little milk. He also showed signs of returning consciousness. Pulse 120, more regular and fuller. Respiration 50. Temperature  $97^{\circ}$  F.

8 a.m.: Still more signs of improvement and more conscious. Was able to take more milk. Pulse 100. Respiration 50. Temperature  $98^{\circ}$  F.  $\frac{1}{80}$  gr. strychnine again given, and also  $\frac{1}{30}$  gr. digitalin.

11 a.m.: Patient was still very restless, but was more conscious, and was able to take a little chicken extract. Pulse 84, full and regular. Respirations 60. Temperature  $97.2^{\circ}$  F. Condition generally was one of improvement. Patient passed a motion of which he was quite unconscious. He was given 1 c.c. pituitary extract hypodermically, and this treatment was continued four-hourly with intermittent doses of digitalin or strychnine. Numerous râles could now be heard all over the chest, both in front and behind, but there was no sign of dullness.

3.30 p.m.: Condition was much the same. Still very restless and slightly less conscious again. Passed another motion. Although patient was conscious of passing his motions, he passed his urine quite unconsciously.

5 p.m.: Patient was slightly worse again and distinctly less conscious. Pulse 128, less full and more irregular again too. Respirations 58. Temperature  $100.2^{\circ}$  F. 1 c.c. pituitary extract again given hypodermically. Ammonia capsules were now being used at the rate of one every half hour.

8 p.m.: Condition much same as at 5 p.m.

11 p.m.: Showed signs of slight improvement. More conscious and less restless. Pulse 92, regular. Respirations 46. Temperature  $99^{\circ}$  F.

September 2, 2 a.m.: Condition much same as at 11 p.m. on September 1. Pulse 102. Respirations 50. Temperature  $98.2^{\circ}$  F.

6 a.m.: More signs of improvement. Patient was more conscious, and was only restless at intervals. Passed another motion. 1 c.c. pituitary extract was again given, and this was the last dose administered for some days. Pulse 84, regular and full. Respirations 36. Temperature  $97.8^{\circ}$  F. Hot water bottles were applied.

10 a.m.: Condition much same as at 6 a.m., but patient was slightly more restless again. Numerous râles could still be heard all over the chest, both in front and behind, but again there was no evidence of dullness or fluid accumulation.

4 p.m.: Patient's condition very satisfactory. He had slept from 3 p.m. Pulse 98. Respirations 40. Temperature  $99.4^{\circ}$  F.

8 p.m.: Progressing favourably. Slept for fifteen to twenty minutes at frequent intervals. Pulse 95. Respirations 40. Temperature  $99.6^{\circ}$  F.

Ordered ammon. carb. 5 gr. t.d.s. The patient was now able to take milk and chicken extract with ease and in appreciable quantities.

From 8 p.m. on September 2 till 9.30 a.m. on September 5: Patient showed signs of great improvement. He slept well, sometimes for two to three hours at a stretch. He was able to take milk, chicken extract, sago and soups. His bowels moved daily, and although he was quite conscious of passing his motions, he still never was conscious of passing his urine. During the period the only medicine prescribed was ammon. carb., 5 gr. t.d.s. Pulse varied from 95 to 62, was always regular and strong. Respiration rate gradually decreased from 40 to 28 per minute. Each respiration was always full and deep and there never was any sign of respiratory obstruction. Numerous râles were audible, both in front and at back of the chest. No dullness was ever detected. Temperature gradually came down from 99°6 to normal.

For the first thirty-six hours after admission the patient was kept lying on a stretcher in the open, but after that he was placed in a well ventilated room.

10 a.m.: At 10 a.m. on September 5, the patient suddenly showed signs of getting worse again. His breathing became more rapid, and to a certain extent became laboured too. His temperature fell from normal to 97° F. His pulse became rapid and weak, and he showed rapidly increasing signs of delirium. Given  $\frac{1}{16}$  gr. of strychnine hypodermically.

2 p.m. to 6 p.m.: Patient was rapidly losing ground. Quite unconscious; vomited once. Pulse-rate rose from 84 to 146, very feeble and irregular. Respiration: Breathing became stertorous and shallow, and mainly abdominal in type. The rate of breathing first increased from 32 to 40 (at 2.30 p.m.) and then gradually decreased to 16 per minute (at 6 p.m.). Temperature at 2 p.m. was 96°4 F.; at 3 p.m., 96°4 F., and then again rose to 98°6 F. at 6 p.m. Patient was packed round with hot water bottles. He was given another  $\frac{1}{16}$  gr. strychnine and shortly afterwards 20 minims of spirit. ammon.

6.30 p.m.: Condition very grave. Breathing very stertorous in type and very shallow. Rate of breathing 20 per minute. Pulse 140, very feeble and irregular. Temperature 99° F. Patient by now had developed very marked nystagmus, internal strabismus, and his right pupil was distinctly sluggish and slightly larger than the left.

7 p.m.: Condition still worse. Pulse 126, very feeble. Temperature, 100°2 F. Respiration very stertorous.

7.38 p.m.: Patient died.

*Post-mortem Observations.*—A post-mortem examination of the brain was made on September 6, and the following noted: No injury to the cranium, either externally or internally, at the site of the scalp wound. No evidence of hæmorrhage either on the surface of the brain, or at the base of the skull.

*On Section.*—(1) Cerebrum: Numerous punctate hæmorrhages scattered throughout both the grey and white matter, and in the grey matter of the right lobe there was one hæmorrhage about the size of a split pea.

(2) Cerebellum: Numerous punctate hæmorrhages in cerebrum, but in

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addition there was one large hæmorrhage about the size of a shilling on the right side, and one about the size of a threepenny-piece on the left side.

(3) Pons: Scattered throughout its substance too, these small punctate hæmorrhages were noticed.

(4) Medulla: Same as the pons.

(5) Fourth ventricle: Both the roof and the floor of the fourth ventricle were studded with numerous punctate hæmorrhages which here were so numerous as to appear almost like one continuous large hæmorrhage.

(Signed) J. W. VAN REENERD, Lieutenant, I.M.S.

The following points are, I think, of interest in connexion with the gas employed in this case, the composition of which I do not know.

(1) It was one that had two different toxic actions—viz., primarily on the cardiac centres, and secondly, much later, on the vascular system, causing a degeneration of the walls of the small vessels, leading to hæmorrhages into the substance of the brain, and probably other organs as well, but they were not examined. There were no serious symptoms apparent at any time of toxic actions on the respiratory centres or organs.

(2) The late appearance of the fatal symptoms, or perhaps it would be more correct to say the delayed action on the vascular system. The patient had survived the critical period of cardiac failure, and was apparently well on his way to recovery when the fatal symptoms appeared—five days after he had been gassed.

Lieutenant-Colonel, I.M.S.,

O.C. 141 Secunderabad I.C.F. Amb.

Unfortunately there are no notes of the condition of the reflexes nor the state of tonus of the muscle of the limbs. The clinical notes do not indicate that this patient suffered with pneumonia, nor any obstruction to the entrance of air to the lungs; there is no statement regarding the cause of the extremely rapid respiration, but the fact that he was given oxygen and diffusible stimulant for the first twelve hours suggests that there was great respiratory embarrassment due to deoxygenation of blood. Later there is a definite statement; there is no evidence of cyanosis and no respiratory obstruction; the oxygen was stopped. But the respiration still continued very rapid—50 to 60. After some days his condition greatly improved, and the respiration fell even to 28. Then on the last day in the morning he suddenly developed grave symptoms, and in the evening it is noted that he developed marked nystagmus, internal



PLATE III.

Section of frontal cortex from case of shell gas poisoning. Hyaline thrombus of vessel in the centre of hæmorrhage. ( $\times 150$ .)

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strabismus, and the right pupil was distinctly sluggish and slightly larger than the left. The conclusions and findings are not inconsistent with CO poisoning, but it may have been some other gas or mixture of poisonous gases.

I was unable to confirm the statement of hæmorrhage into the pons and medulla. The vessels were congested, but no hæmorrhage was found. The cerebral hemispheres were badly preserved, and I was only able to examine the cerebral cortex of the frontal lobes.

*Microscopic Examination.*—Portions of the frontal cortex and subjacent white matter, showing to the naked eye miliary punctiform hæmorrhages, were taken, and, as in all the other cases, blocked in paraffin, and sections cut and stained by Van Gieson and hæmatoxylin-eosin methods, also with polychrome. The punctiform hæmorrhages appeared in some of the sections to form a circle of circumscribed, discrete, oval or round areas of extravasated blood, often with a section of a vessel in the centre or proceeding to the hæmorrhagic area. In sections stained by the Van Gieson stain the lumen and the thin-walled vessels so seen appear a pale pink, and this presumably is due to the contained hyaline thrombus (Plate III).

In some vessels red blood corpuscles are seen with abundant fibrin formation; a similar appearance to that seen in the alveoli in red hepatization; other vessels appear filled with polymorphonuclears and fibrin. Around the central thrombosed vessels of the hæmorrhage are seen deeply stained pink areas of necrosed brain tissue infiltrated with polymorphonuclear leucocytes; very often a vessel can be seen filled with blood which is extravasated into the sheath, and occasionally the rupture of a thin-walled vessel causing hæmorrhage into the perivascular sheath can be seen. This condition of central thrombosis with necrosis of brain tissue around and infiltration of leucocytes is similar to that observed in the CO poisoning from the nickel works, when the patient lived eight days; and is in accordance with what might be expected, seeing that the man lived six days after possible inhalation of the gas.

#### SUMMARY.

The reason why these punctiform hæmorrhages occur in the white matter of the brain is primarily due to the anatomical condition of the vessels in the white matter of the cerebrum, where the arteries are terminal; each small artery having a separate capillary system, likewise the emerging veins. A tendency to stasis may be brought about in

these separate vascular systems by the failure of the heart as a force pump and suction pump, also by those respiratory conditions which lead to right heart dilatation, and interference with the return of blood from the skull. In most cases the two factors are combined. It seems probable, however, that either factor may act independently as a coefficient of gas poisoning in causing inflammatory stasis and thrombosis, resulting in multiple punctiform hæmorrhages. In the gas case, in which the hæmoglobin has been converted into pigment granules, it seems probable that the hæmorrhage may be accounted for by embolic occlusion of the arteries. It is unfortunate that with the exception of the case of CO poisoning by illuminating gas I have not had the opportunity of examining the organs of the body.

It is quite probable that, as in that case, fatty degeneration of the heart, the kidneys, liver, and vessels of the brain would be found to exist.

In conclusion, I desire to acknowledge my indebtedness to my assistant, Mr. Charles Geary; also to Miss Munro and Miss Watson for the assistance they have afforded me, and to the Board of Control for a grant to enable me to give them an honorarium for their services.

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December, 1917.*

THE MICROSCOPIC EXAMINATION OF THE BRAINS OF  
TWO MEN DEAD OF COMMOTIO CEREBRI (SHELL  
SHOCK) WITHOUT VISIBLE EXTERNAL INJURY.<sup>1</sup>

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THE examination of the brains of two cases of death from shell shock without visible injury and without punctate hæmorrhages indicative of gas poisoning is of interest for several reasons. So far as I know, it is the first description that has been given which serves to explain (1) sudden death in shell shock, and (2) the clinical symptoms which persist for some time after the commotion of the brain in non-fatal cases.

I am indebted to Lieutenant-Colonel T. R. Elliott and Professor Arthur Keith for sending me the brains, and to the officers whose names are mentioned for the clinical notes and the notes of the post-mortem examination.

CASE 1.—CLINICAL NOTES.

In this case the man developed, according to a note furnished by Captain J. London, a degree of nervousness on the Somme which he never lost, but was able to control for six months. Later he was in an area which was subjected to an intense bombardment, during which, as far as can be ascertained, no gas shells were used. This lasted about four hours (February 22, 4 p.m. to 8 p.m.). Although he remarked to another man that "he could not stand it much longer," he did not give way until the following day, twelve hours later, when perhaps six shells came over (February 23, 8 a.m.).

He was not buried nor gassed. One shell burst just behind his dug-out—namely, ten feet away—in the morning, but many must have been as near the previous day. Early symptoms were tremors and general

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<sup>1</sup> The expenses connected with the microscopic investigation and illustration of this communication have been defrayed by a Government grant of the Board of Control.

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depression. The later symptoms (February 22) were coarse tremors of the limbs, crying (February 23), inability to walk or do anything. He would not answer questions—very like the hysterical manifestations of melancholia. The pupils were dilated. I was rather busy with some wounded at the time, and did not make a detailed examination.

A note by Captain Francis A. Duffield, R.A.M.C.(S.R.), states that the man was admitted to the field ambulance in the evening in a state of acute mania, shouting "Keep them back, keep them back." He was quite uncontrollable and quite impossible to examine. He was quieted with morphine and chloroform, and got better and slept well all night. In a later note, Lieutenant-Colonel F. J. Crombie, in command of the field ambulance, stated that the patient had at least two hypodermic injections of morphine while in the ambulance. Next morning he woke up apparently well, and suddenly died.

### *Necropsy.*

The following is a note by Captain A. Stokes, R.A.M.C. (Mobile Laboratory), on the post-mortem examination made on the afternoon of the day of death.

There were no marks of external violence on the body other than some small scratches on the chest wall.

*Thorax.*—The lungs were œdematous, and in the substance of the lower lobe of the left lung there was a considerable hæmorrhage. The right lung, except for œdema, was normal.

*Heart.*—Enlarged, and the right side dilated. The muscle was good, and there were no valvular lesions.

*Abdominal Cavity.*—Normal. There was no pathological change in the stomach, œsophagus, intestine, or great intestine. The liver was normal in size, and was somewhat congested. The spleen was normal. The kidneys were small, but showed no gross change. The urine contained neither sugar nor albumin.

*Skull.*—There was a slight bruise on the scalp, in the frontal region. The brain was extremely congested, and on each side of every superficial vessel there was an ecchymosis. There were a number of minute punctiform hæmorrhages at the terminations of the smallest vessels on the surface of the brain. The whole brain was soft but not markedly œdematous. The cerebrospinal fluid appeared to be blood tinged. There was considerable ecchymosis on each side of the great sinuses of the skull. There was no large hæmorrhage found, and no small intracerebral petechiæ. There was no gross lesion of the viscera, which would have been a cause of death; but though I have never seen a post-mortem examination on a man who has died of "shell shock," I consider the condition of the brain is consistent with that diagnosis.

## MICROSCOPIC EXAMINATION OF THE BRAIN OF CASE 1.

The brain had been preserved in Kaiserling's fluid, and it was not in very good condition, but seeing that it was placed in this fluid less than twelve hours after death, it is probable that the portions examined yielded satisfactory material for microscopic investigation.

The portions of brain selected were prepared for section by the paraffin method of serial sections. The dyes used to stain the sections were as follows: (1) Hæmatoxylin and eosin; (2) Van Gieson; (3) thionin; (4) polychrome and eosin. The sections were five microns in thickness and were mounted, after staining, in Canada balsam.

*Cerebrum: Top of Ascending Frontal Convolution; Leg Area.*—The veins are congested both in the meninges and in the substance of the grey and white matter. There is subpial hæmorrhage here and there owing to rupture of the dilated congested veins. There are no punctate hæmorrhages observable. The perivascular spaces of the arterioles, capillaries, and venules are dilated, also the perineuronal spaces are distinctly seen, some being apparently connected with the perivascular spaces. In some of the sections, empty collapsed vessels can be discerned in places. The general appearance suggests deficiency of blood in the arteries and capillaries, with engorgement of the venous system. A condition very similar to that observed in experimental anæmia in animals produced by ligation of both carotids and vertebrals. There is some degree of chromatolysis of the cells. The Betz cells are the easiest on account of their size to recognize this change, and the accompanying drawing (fig. 1) shows the early chromatolysis of these psychomotor neurones. The pole of the first frontal shows marked congestion of the vessels and some subpial hæmorrhage from dilated congested veins. Many of the arterioles and capillaries are empty and collapsed, and there is the same appearance of dilation of the perivascular sheaths and perineuronal spaces. The pyramidal cells also show early chromatolytic changes.

*Internal Capsule.*—There is general congestion of veins, and the small vessels appear to be either empty and collapsed, or contain less blood than normal. Some of the vessels show hæmorrhage into the sheath. (Fig. 2.)

*Corpus Callosum.*—The small vessels are congested and dilated, some have ruptured into the sheath, other small vessels have ruptured into the tissue. There are no typical punctate hæmorrhages

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such as are seen in gas poisoning, which are due to hyaline thrombosis of terminal arterioles.

*Pons.*—There is a marked congestion of veins and some of the smaller veins have ruptured, giving rise to hæmorrhage into the sheath, blood corpuscles are also seen extravasated in the adjacent nervous tissue. There are small hæmorrhages in the white matter (fig. 3). There is dilatation of the perivascular sheaths and perineuronal spaces together with collapsed and empty vessels or partially empty vessels. The hæmorrhages, here as elsewhere, appear to be of recent occurrence. Nearly all the cells show some degree of early chromatolytic change.

*Medulla.*—Sections of the medulla at the point of the calamus scriptorius were made, as the upper part of the medulla was rather damaged. In the anterior median fissure a vessel had ruptured, and there were free corpuscles in the lepto-meninges. All the veins on the surface of the medulla were congested. In serial sections the ruptured vessel entering the anterior median fissure and penetrating the median raphe could be followed, and here it was seen to have ruptured into the perivascular space (fig. 4), and blood corpuscles are seen extravasated into the adjacent tissue. The perivascular and perineuronal spaces are seen dilated both in the medulla and pons (fig. 7). The cells of the medulla show only chromatolytic changes as a rule. The cells of the vago-accessorius nucleus (fig. 5) show much more chromatolysis than the adjacent cells of the hypoglossal nucleus (fig. 6). These nuclei are distant about two millimetres from the ruptured vessel in the median raphe.

*Cerebellum.*—Sections stained with thionin and safranin show very unequal staining of the Purkinje cells with the basic dye (fig. 10). This condition is very similar to that described by Crile in the case of "a soldier who had suffered from hunger, thirst, and loss of sleep; had made the extraordinary forced march of 180 miles from Mons to the Marne; in the midst of that great battle was wounded by a shell; lay for hours waiting for help, and died from exhaustion soon after reaching the ambulance."

#### *Summary of Histological Changes.*

There is a generalized early chromatolytic change in the cells of the central nervous system. This change varies in intensity. The cells most affected are the small cells in which the basophil substance has almost disappeared. In the larger cells the Nissl

granules are smaller and not packed so closely together as normal. The small cells of the medulla and pons are slightly swollen, and the nucleus is large and clear. This change is present in some of the large cells, but it is less evident. This change indicates a relative degree of exhaustion of the kinetoplasm; assuming that the amount of the basophil substance is an index of biochemical neuropotential. The Nissl granules are not present in the neurone during life, but they disappear altogether in a cell that (prior to death of the whole body) has been so injured as to decay and die. Granted this premise, then, it may be assumed that the cells of this man are in a state of commencing nervous exhaustion, some nuclei of cells showing the changes more markedly than others—for example, the cells of the vago-accessorius nucleus.

The vessels of the pia-arachnoid membranes of the brain are congested, and there are scattered subpial hæmorrhages of microscopic size almost everywhere.

In the white matter of the corpus callosum, the internal capsule, the pons, and medulla there are seen congested veins and hæmorrhage into the sheaths of these vessels with occasionally extravasation of blood corpuscles into the adjacent tissues.

#### CASE 2.—CLINICAL NOTES.

Captain Duffield reported that information obtained from the medical officer attached to the unit in which the man, a gunner in the Royal Garrison Artillery, was serving, was to the effect that he was sitting in a corrugated iron hut, fifty yards from some boxes of cordite cartridges, when a shell landed and exploded them. The man became unconscious at once, his breathing was stertorous: his body showed no signs of wounds.

On the same day he was removed to a dressing station and thence to a casualty clearing station; in the evening of that day he died. The medical officer there stated that the patient was absolutely unconscious, and could not be roused. His breathing was stertorous and slow; the pupils were equal and reacted to light; knee-jerks were difficult to obtain. He died shortly afterwards, and at the post-mortem examination the brain was removed, placed in spirit, and dispatched.

#### *Macroscopical Appearance of Brain of Case 2.*

On the upper surface of the cerebellum, the temporo-sphenoidal, and left orbital lobes there was superficial hæmorrhage. On cutting up the pons, oval patches were seen as large as  $\frac{1}{8}$  by  $\frac{1}{4}$  inch; whether

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this is simple staining of hæmorrhage cannot be determined until a microscopical examination has been made. Portions of the mesencephalon and pons were taken for microscopical examination; the medulla oblongata was not sent.

### *Microscopical Examination.*

*Post-parietal.*—Meninges: Marked congestion of all vessels of the surface of the brain with extravasation of blood into the soft membranes. In the grey matter of the cortex the perivascular spaces are dilated throughout, and the capillaries, veins and arteries are for the most part empty. In the white matter no punctate hæmorrhages are seen; there is marked dilatation of the perivascular spaces; the capillaries, veins, and arteries are empty. In the cortex there is dilatation of the perineuronal spaces, which in many instances may be seen communicating with the perivascular spaces. (Fig. 8.)

*Ascending Frontal.*—Stained with thionin. The large pyramidal cells show pretty marked chromatolysis without swelling of cell; some of the Betz cells show commencing breaking up of the tigroid bodies; smaller pyramidal cells show undoubted swelling of nucleus and loss of pyramidal shape, very similar to that observed in experimental anæmia in animals, with varying degrees of chromatolysis. As a rule, the smaller the cell, the more marked is the change. (Fig. 9.)

*Orbital Lobe.*—On the under surface there is extensive extravasation of blood into the substance of the brain and on the surface, and there is very marked dilatation of the perivascular spaces everywhere. The cortex is in a measure destroyed in one place; there is very marked dilatation of perineuronal as well as perivascular spaces, which intercommunicate.

*Corpus Callosum.*—There is much congestion of vessels, and many have ruptured into the sheath, forming long, irregular branching, hæmorrhagic extravasations, but no sign of punctiform hæmorrhage.

*Temporo-Sphenoidal Lobe.*—Shows remarkable dilatation of the perivascular spaces, and there is a big globular hæmorrhage, and much hæmorrhage into the substance of the brain.



OPINIONS OF FRENCH AND GERMAN OFFICERS REGARDING  
"SHELL-SHOCK" BY WINDAGE.

Many discussions have taken place by French and German neurologists regarding the question of organic changes occurring in the central nervous system as a result of *vent du projectile* or windage. According to Léri, a true commotion appears only to be produced at a proximal distance of some ten metres from great projectiles. The finding of groups of men dead in the last attitude of life, in closed spaces such as the German "pill-boxes" and concrete dug-outs, and the proven fact that enormous forces of compression and decompression are generated by the detonation of high explosives in great shells, aerial torpedoes, and mines has lent support to the view that mere proximity to the explosion is sufficient to cause organic changes in the brain and spinal cord by the compression and decompression of gases, the result of the explosion, and of the atmospheric air; altogether apart from actual concussion caused by violent contact with solid materials, such as sandbags or the earth forming the walls of a dug-out, which may at the same time cause burial or partial burial, unattended by visible evidence of injury of the body sufficient to account for symptoms of cerebral or spinal concussion. The patient is rendered unconscious and his mind is a blank concerning what happened, in a true case of *commotio cerebri*; consequently he is unable to say whether he had or had not been concussed by the sand or earth. In the two cases under consideration there was no history of burial.

Undoubtedly the vast majority of non-fatal cases of shell-shock are more emotional in origin than commotional, and occur especially in subjects of an inborn neurotic or neuropathic temperament; but the two conditions may be associated. Both Léri and Meige emphasize the fact that commotional symptoms are not influenced by psychotherapy. They also point to the fact that in cases where organic changes have occurred the cerebrospinal fluid withdrawn by lumbar puncture exhibits macroscopic or microscopic evidence of blood indicating that hæmorrhage had occurred.

In Case 1 Captain Stokes noted at the post-mortem examination that the fluid was blood-stained, and the microscopic findings of ruptured vessels explain this.

Léri states that the subjects of commotion are generally depressed, asthenic, aboulie, and often more or less confused mentally; they present almost constantly, even in light cases, pro-

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nounced disturbances of voltaic vertigo. They often suffer with bleeding from the ear, or nasal or vesical hæmorrhage. Roussy and l'Hermitte admit that in rare cases "vent du projectile" may cause organic changes.

Robert Bing gives a review of the German opinions upon nervous accidents determined by the near explosion of a projectile. He points out that Vogt and Gaupp, who have occupied themselves with "Granat Kontusion" (bomb contusion), are far from accepting the exclusive psychogenic rôle in the development of this syndrome. Gaupp insists particularly upon the relations which exist between the initial symptoms presented by those patients and the rapid succession of atmospheric compression and decompression which takes place at the moment of the bursting of the projectile. The existence of labyrinthine lesions, almost regularly in this class of case, is in support of this opinion (Schultze and Meyer).

In von Sarbo's numerous publications upon the subject there is a tendency to regard these cases from a uniform point of view. For him the general mass of observations do not permit the diagnosis of organic changes in the usual sense of the word, nor that of psychoneurosis. He believes microstructural alterations occur, but which are not equivalent to the molecular changes of Charcot. He includes in the microstructural changes meningeal œdema, microscopic hæmorrhages, transitory paralysis of vessel walls, and contusion of the nuclei and centres. In the initial period these lesions may give rise to some discrete symptoms of organic disease; later they are manifested by functional physical and psychical symptoms. Bing remarks that the pseudo-neurasthenia of arteriosclerosis supports this view. It is interesting to note that the hæmorrhages into the perivascular sheaths of vessels observed in Case 1 resemble in some respects those seen in arteriosclerosis.

Oppenheim's view of traumatic neuroses had few supporters at the Congress at Munich.

Aschaffenburg examined soldiers in Flanders who had been exposed to shell fire in the trenches but had escaped unwounded and were apparently well. The examinations took place in most cases within twenty-four hours after leaving the trenches. Of seventy-four men so examined, sixty-seven showed unmistakable signs of localized organic lesions of the nervous system, although not as a rule of a serious nature. A second examination a week later showed that some, but not all, of these phenomena had disappeared. Here were cases, therefore, in which an organic basis was present but no traumatic neuroses had developed. Aschaffenburg gives the result of his experience in these words:—

"In assuming organic changes one of the consequences of shell explosion I do not thereby agree with Oppenheim that the nervous symptoms are to be attributed to these changes. On the contrary it is to be noted that the most exaggerated hysterical cases which develop after exposure to shell firing are the ones which exhibit organic symptoms least of all."

*Hypotheses regarding the Lesions of "Commotion."*

Two hypotheses have been put forward to explain organic lesions by "commotion."

(1) Compression of the gas and atmosphere, so that the cranium and spine are struck, as it were, by a solid body and the vibration is transmitted through the bony structures to the cerebrospinal fluid and thence to the brain and spinal cord, causing a molecular disturbance of the delicate colloidal structures of the neurones particularly those of the nuclei in the floor of the fourth ventricle where the fluid is most abundant, and where it acts as a water cushion upon which the vital cardio-respiratory centres rest.

(2) Compression is followed by a corresponding decompression causing the liberation of bubbles of gas in the blood and tissues leading to embolism.

Probably both the forces of compression and decompression act in producing vascular disturbances in the central nervous system, causing arterio-capillary anæmia and venous congestion and rupture of delicate-walled vessels with microscopic hæmorrhages.

COMMENTARY.

In Case 1, of which I have described the histological changes, it may be observed that there was a condition of mania during life; this maniacal excitement may be correlated with the marked venous congestion of the cortex, the microscopic subpial hæmorrhages, and a certain degree of scattered arterio-capillary collapse and emptiness. This, however, could not be held responsible for the suddenly fatal termination; the hæmorrhage into the sheath of a fair-sized vessel (see fig. 4) in the median raphe of the medulla and the generalized congestive venous stasis, with a condition of exhaustion of the cells of the vago-accessorius nucleus (as shown by the almost complete disappearance of the Nissl granules (see fig. 5) as compared with the cells of the adjacent hypoglossal nucleus), coupled with the condition of the heart found post mortem, may explain the sudden death.

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The cerebral anæmia, as shown by collapsed and empty arterioles and capillaries with dilated perivascular and perineuronal spaces (see figs. 7 and 8), similar to the appearances in sections of brains of animals that have been killed within a few days of ligation of both carotid and vertebral arteries. The veins are congested similarly, but the capillary anæmia would explain many of the symptoms of sufferers with true shell shock, namely, headache, giddiness, amnesia—anterograde as well as retrograde—dizzy feelings, lack of power of attention, and fatigue—stupor, inertia, mental confusion, terrifying dreams—symptoms which are generally met with in recent cases.

There is, in both Cases 1 and 2, a general, though as a rule not marked, chromatolytic change indicative of a lack of kinetoplasm in the neurones of variable degree. This may hypothetically, but with reason, be regarded as an expression of a fall in the general store of neuro-potential of the central nervous system. The cells of Purkinje of the cerebellum show especially a complete or partial loss of the basophil substance.

The vascular changes are microscopic and widespread; there are no punctate hæmorrhages of the white matter, such as I have described in gas poisoning, and which are due to a hyaline thrombosis of terminal arterioles. The hæmorrhages are into the dilated perivascular sheaths (see figs. 2 and 3). In the corpus callosum the networks of capillaries and small vessels show fractures and escape of corpuscles into the tissues. The microscopic changes in the brain confirm in every way the opinion expressed by Captain Stokes when he made the post-mortem examination that he was dealing with a case of shell shock.

In Case 2 the extensive hæmorrhage on the under surface of the orbital lobe without visible external injury is of interest. The force of the explosion must have been enormous. What happened to the man when it occurred we do not know. The cortical arterial and capillary vessels were empty, the perivascular sheaths were dilated and filled presumably with cerebrospinal fluid (see fig. 8). The cortical neurones are swollen up, the nuclei are large and clear; the basophil substance is diminished in amount, a condition very like that observed in the cells of the cortex of an animal in which experimental cerebral anæmia had been effected. Owing to the brief clinical and post-mortem notes this case is of much less interest than Case 1.

I am unable to find in the literature at my disposal any description of the microscopic changes in the brains of soldiers dying from *commotio cerebri* without visible external injury.

MICROSCOPIC INVESTIGATION OF THE SPINAL CORD IN A CASE  
OF PROBABLE SPINAL COMMOTION.

## 1.—CASE NOTES.

1929 Pte. A. —, 16th Middlesex. Died July 8, 1916. This man was badly wounded on July 1, 1916, during the early advance. He was brought in from "No Man's Land" on the evening of July 5, 1916, and arrived at the Casualty Clearing Station on the morning of July 6, 1916.

There was a superficial graze (probably caused by shrapnel) over the spine of the left scapula, and a small "in and out" wound over the right gluteal region. This wound was about two inches long, and superficial. It was clean, and the muscles were not involved. He had had tetanus antitoxin (quantity unknown). His mental condition was fairly clear, although somewhat masked by his halting speech and extreme somnolence. He was, of course, much fatigued, and had suffered from lack of food. He had complete paralysis of the legs and abdominal muscles and the left side of the face. There was marked equal loss of power in both arms. Complete anaesthesia from the level of the umbilicus downwards, atony of the bladder with overflow incontinence, and loss of control of the rectum were present.

The pulse varied between 80 and 90 per minute, but was weak in tension. There was no albumin in the urine. He merely became weaker; eventually coma preceded death on July 8, 1916, without any additional symptoms having presented themselves.

Post mortem: complete examination was made, and nothing to account for death was found.

(Signed) WILLIAM MOODIE,  
Captain R.A.M.C.  
O.C. 17 Mobile Laboratory.

## MICROSCOPIC EXAMINATION OF PORTIONS OF THE SPINAL CORD.

A portion of the spinal cord extending from the eighth dorsal to the fourth lumbar segment was sent to me for examination by my former assistant, Captain Moodie. The material arrived in good condition in formol solution. Portions were blocked in paraffin, and sections of five microns were cut and stained by Van Gieson, Nissl, and Leishman stains; the last named yielded the best results.

The eighth, tenth, twelfth dorsal, first and second lumbar segments were examined; similar appearances, although the changes varied in intensity and degree, were observed in all the sections. Briefly they were as follows: On the surface of the spinal cord blood corpuscles were seen adhering—evidence that the cerebro-spinal fluid had contained blood during life. The veins upon the

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surface of the spinal cord were everywhere congested ; the arteries and capillaries as a rule were empty. In places the *veins* could be seen *ruptured*, and in some sections *intraradicular hæmorrhage* was observed. In the substance of the spinal cord itself were numerous minute hæmorrhages, varying in size from a pin's head, and visible to the naked eye, to a pin's point, invisible except by aid of the microscope.

The hæmorrhages are seen especially in situations where the surrounding tissue offers least support ; consequently they are found in the grey matter of the anterior horns, but especially at the base of the posterior horn near the central canal (*vide* figs. 11 and 12).

Frequently small veins are observable both in the grey and white matter which have ruptured, and numbers of the escaped red corpuscles are seen in the perivascular sheath.

There are distinct changes in the anterior cornual cells of varying intensity. There is perivascular chromatolysis, and not infrequently there is some swelling of the cell and eccentrically placed nucleus (fig. 13). These changes do not seem to bear a direct relationship to the hæmorrhages ; it is probable that the finding of these wide-spread capillary and venous ruptures with blood extravasation is important in showing the violence of the commotion to which the delicate fibrils, forming the neuronie synapses in the grey matter, have been subjected. Mechanical compression by the escaped blood corpuscles probably plays only a minor part in producing the loss of function. Had an examination of the cervical cord, of the bulb, and of the pons been made, no doubt similar changes would have been found to account for the symptoms noted. The anæsthesia below the level of the umbilicus likewise may be accounted for by the damage to the grey matter especially noted at the base of the posterior horns.

From the situation of the wounds caused by shrapnel (pieces of the shell ?) it is probable the main effect of the commotion was upon the lower part of the spinal cord.

Bearing upon this question of commotion I will refer to an interesting article by A. Mairet and G. Durante, on the "Com-motional Syndrome," which was published in the *Presse Médicale*, June 15, 1917. They have experimented upon rabbits by means of powerful explosives in order to try and find out what happens to soldiers in the trenches.

A charge of melinite or chédite placed at 1·50 metres, then at 1 metre, was successively raised from 125 grammes to 1 kilogramme.

Of twelve animals used five died spontaneously, respectively in five minutes, one hour, one day, eight days and thirteen days after. The others after a momentary unconsciousness with acceleration of respiration and temporary excitement, sometimes rapidly recovered and were killed, with the result that no signs of local lesions were present. Histological examination in all the animals that died showed early lesions consisting of more or less extensive islands of pulmonary apoplexy, caused by rupture of alveolar capillaries. In most cases hæmorrhages and suffusions of blood were found on the surface of the spinal cord, also in the roots between their emergence from the cord and at their conjugation ; also limited ruptures of small vessels in the grey matter of the cortex and of the bulb, causing a blood effusion into the perivascular lymphatic sheath, were found.

More rarely perivascular suffusion of the radiate vessels of the medulla oblongata and of small vessels behind the ependyma were observed. The nerve cells were healthy. Vascular changes were found in the anterior horn and spinal ganglia only in two rabbits, and hæmorrhages in the kidney were found in one animal.

The hæmorrhages especially occur from vessels which are badly supported by surrounding tissues, the blood then escapes into the perivascular lymph sheath which does not offer any support. The hæmorrhages are minute, and are diffused, and this fact speaks in favour of a sudden rupture of the wall caused by the decompression which suddenly follows on the wave of compression.

These changes observed by Mairet and Durante are very similar to those which I have described in the cases examined.

It will be noted that in Case 1 there was pulmonary hæmorrhage found at the autopsy.

#### COMMENTARY.

We do not know what happened to this man, but the shrapnel wounds and the condition of paraplegia, together with the histological microscopic findings in the spinal cord, strongly support the view that a large shell burst near by, wounding him and causing spinal commotion but without injury of the spine. He may have been blown up in the air and thrown violently on the ground, but this seems unlikely, as the notes state that his mental condition was unimpaired and there was no visible injury of the spine ; consequently the most plausible explanation of the cause of the pathological condition of the spinal cord is commotion. No cause for

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death could be found except shock. It is a pity that the medulla oblongata and the upper part of the spinal cord with the phrenic nucleus were not sent for examination.

Several cases of spinal concussion without visible signs of injury have been under my care and have so far recovered that they could be discharged from the hospital, and I will briefly relate one case in which I diagnosed spinal commotion and hæmorrhage.

Pte. C., 8th Seaforths, aged 20, was admitted January 5, 1917, with two years' service, six months under fire. On December 22 he was buried in a dug-out by the explosion of an 8·6 shell which struck the back of the dug-out. He was standing up at the time and he remained in the upright position, never lost consciousness, was got out in a few minutes. He was sent to Havre and then to the Maudsley Hospital. Catheterized three days at Havre. On admission he had *incontinence of urine and feces*.

### SENSORY SYMPTOMS.

Except slight hyperæsthesia of epigastric region, no sensory disturbances were detected.

There was no evidence of bruising nor any tender spot over the spine.

There was no evidence of paralysis of face or tongue.

There was marked weakness of arm muscles. Right more marked than left. Could grip slightly; he was able to lift arm above head; he was able to turn over in bed. Very slight power of movement in legs, the movement of the knees better than ankles. No muscular wasting, no marked flabbiness. Patellar and ankle clonus on both sides. Plantar extensor on both sides. Wrist tap and triceps jerk obtained easily.

Pupils normal. No ocular paralysis or nystagmus.

Hearing and sight unaffected, also taste and smell.

He had no signs of emotional disturbance; he had no headache. He did not dream, and invariably replied "All reet" when asked how he felt. In about a month he recovered power over his bladder and the bowels opened naturally. Movements in arms and legs also increased, and he was able to sit on the edge of the bed and put his feet on the ground. Two months after admission he was able to stand and walk with the assistance of two men. The right hand grip was still weak but the left improved. Three months after admission he was able to walk with the aid of a stick and was sent to a convalescent hospital, where he made further progress.

There were no visible signs of injury in this case, but here we see that the whole wall of the dug-out was blown in and buried him; the force of the explosive was communicated to the spinal column by the solid earth. This man suffered spinal concussion



and shock ; but the persistence of the plantar extensor response, ankle clonus and patellar clonus, and the loss of voluntary power pointed to damage of the upper motor neurones, and degeneration of the pyramidal tracts. The absence of sensory disturbance might be thought to be against microscopic hæmorrhages, such as have been found in the histological investigation. We know however by experiments on animals that the path for sensation is not localized in the same way as that for voluntary movement, and that hæmorrhages might occur at the base of the anterior horn destroying the terminal fibrils of the pyramidal tract fibres at their synapsis with the anterior horn cells without closing the sensory path. The shock effect would contribute largely to the loss of power of voluntary movement in the limbs, and the control of the bladder and bowel. The recovery which was made shows that shock, as well as organic changes in the spinal cord, was accountable for the symptoms.

The examination of the spinal cord of the fatal case described indicated to my mind that the lesions were not so severe and gross that he could not have recovered had it been possible to bring him to hospital sooner. His paraplegic condition, in my judgment, was largely due to commotional shock more than actual organic change. The microscopic changes discovered in the grey matter are the visible evidences of the severity of the shock to the spinal cord in its most sensitive and delicate structure, viz., the fibrillary synapses through which are transmitted volitional impulses and sensory impulses from superficial and deep structures.

The biochemical oxidation processes incidental to the transmission of nervous impulses from one system of neurones to another, take place at the synapses, possibly as Professor Marinesco suggests, under the influence of an oxidase ferment.

The intercalary neurones, second type of Golgi, whose axons never leave the grey matter, are always interposed between the neurones of the first type. Thus in the path of voluntary movement the axons of the psychomotor neurones of the motor area of the brain break up into a brush of fibrils at the base of the posterior horn where they are connected with intercalary neurones, which again are connected with the dendrons of the spinal motor neurones, the axis cylinders of which terminate in the voluntary muscles. We have seen that the most vulnerable part of the cord to commotion is the base of the posterior horn. At first there is a flaccid paralysis because the whole sensory reflex arc is knocked out ; but as this shock effect passes off, the less vulnerable sensory

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reflex path is again opened up, but the inhibitory influence of the more vulnerable psychomotor path on spinal reflex action having been lessened, if not abolished, the plantar reflex becomes extensor, ankle clonus is obtained and the deep reflexes are exaggerated.

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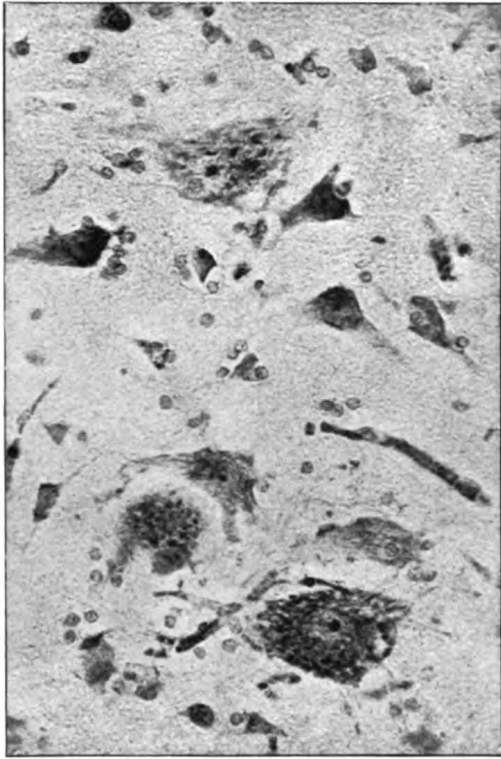


FIG. 1.

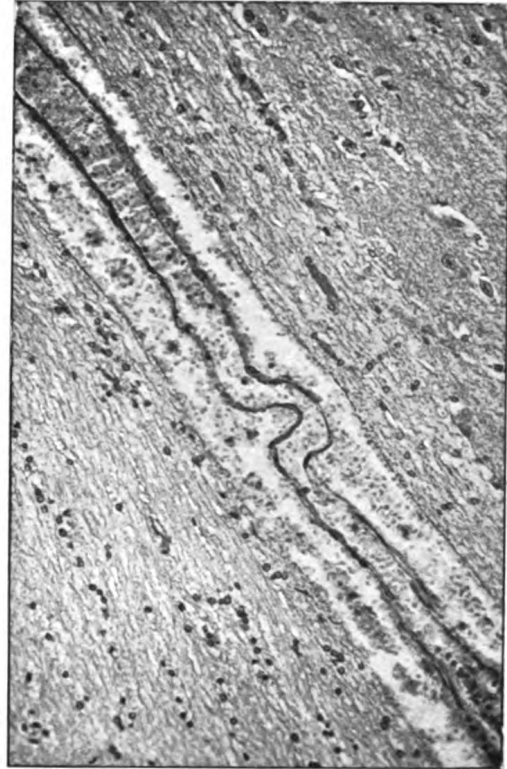


FIG. 2

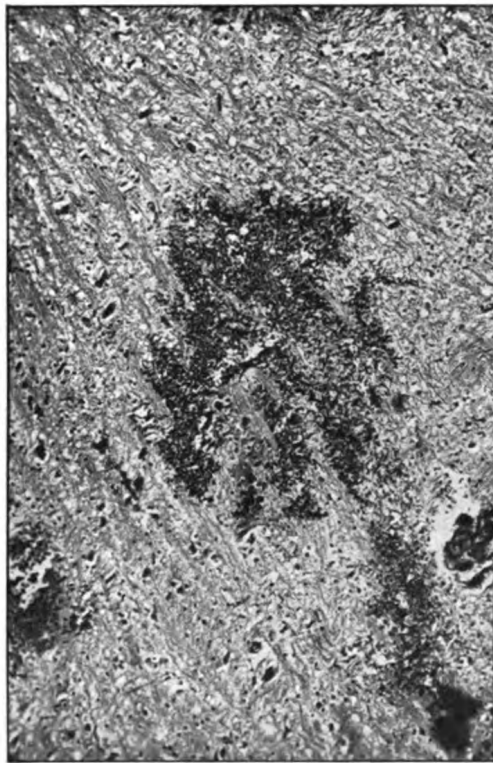


FIG. 3.



FIG. 4.

To illustrate "The Microscopic Examination of the Brains of two men dead of Commotio Cerebri (Shell Shock) without visible external injury," by F. W. MORT, M.D., LL.D., F.R.S., F.R.C.P., Major R.A.M.C.(T.).





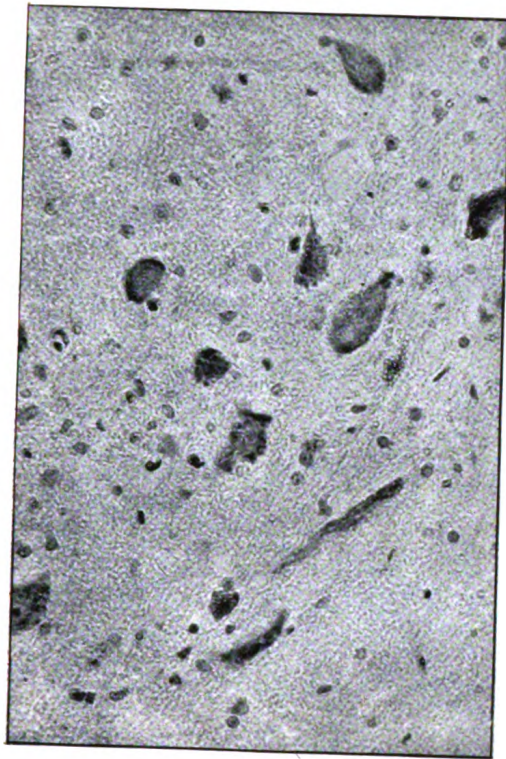


FIG. 5.

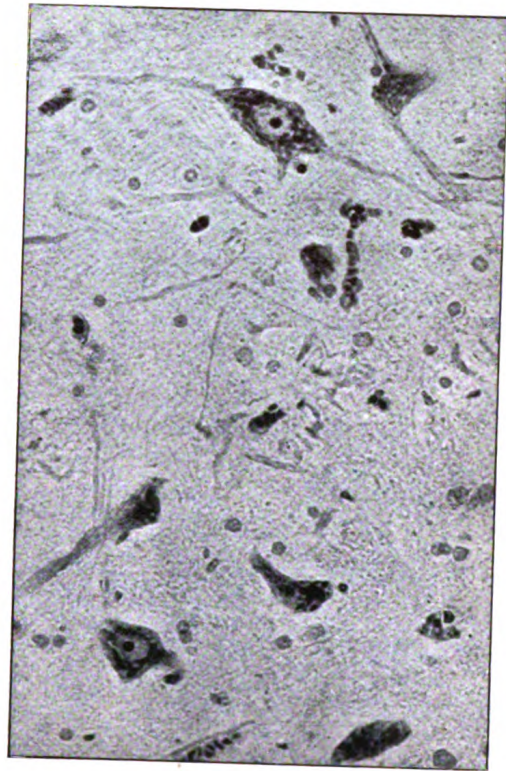


FIG. 6.

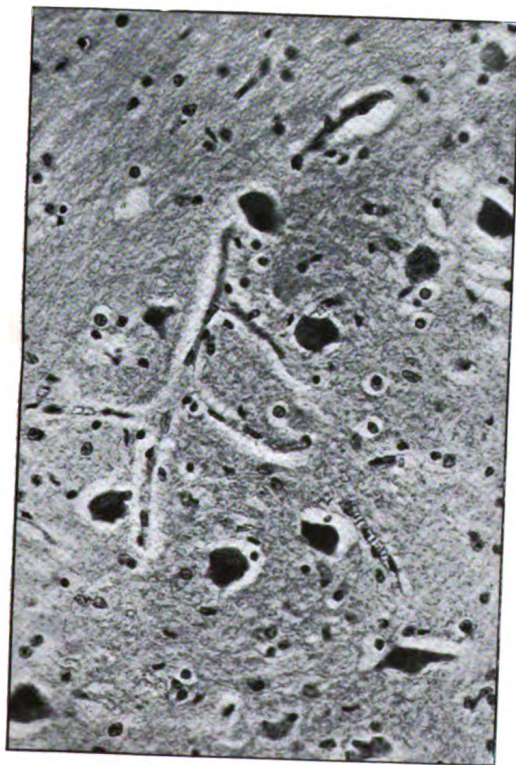


FIG. 7.

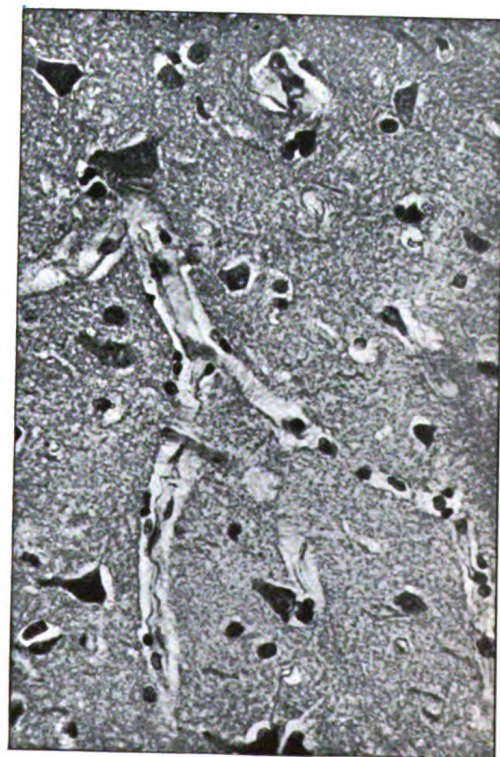


FIG. 8

To illustrate "The Microscopic Examination of the Brains of two men dead of Commotio Cerebri (Shell Shock) without visible external injury," by F. W. Mott, M.D., LL.D., F.R.S., F.R.C.P., Major R.A.M.C.(T.).







FIG. 9.

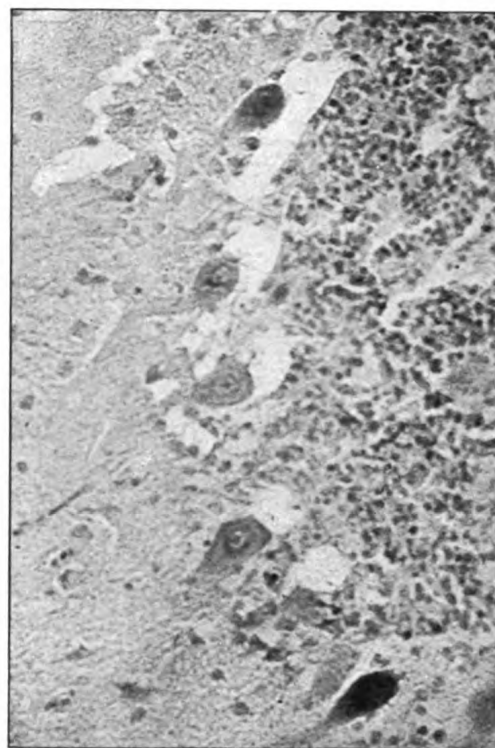


FIG. 10.

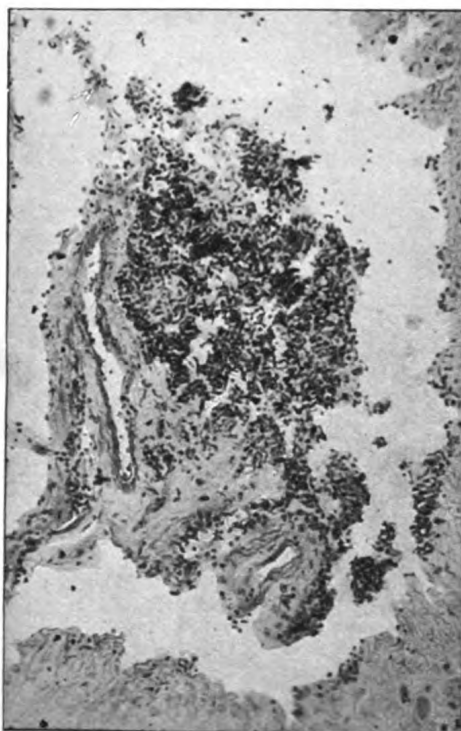


FIG. 11.

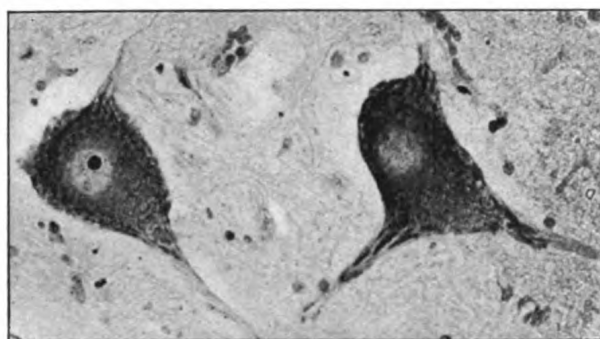


FIG. 12.

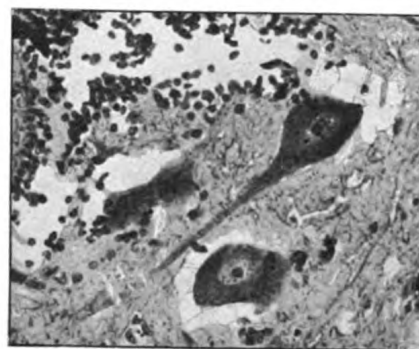


FIG. 13.

To illustrate "The Microscopic Examination of the Brains of two men dead of Commotio Cerebri (Shell Shock) without visible external injury" (Figs. 9 and 10), and "Commotion of the Spinal Cord" (Figs. 11, 12, 13), by F. W. Mott, M.D., LL.D., F.R.S., F.R.C.P., Major R.A.M.C.(T.).





## DESCRIPTION OF FIGURES.

FIG. 1.—Betz cells of leg area. There is commencing chromatolysis of varying degree. The Nissl granules are not so closely packed together as in normal cells. The nucleus is larger and clearer than normal. Magnification 350.

FIG. 2.—A small vessel cut longitudinally in the internal capsule. The vessel is filled with blood corpuscles; the perivascular sheath is seen dilated and filled with red blood corpuscles. Magnification 225.

FIG. 3.—Hæmorrhages into the white matter of the pons. Magnification 90.

FIG. 4.—Hæmorrhage into the sheath of a vessel in the median raphe of the medulla. Magnification 170.

FIG. 5.—Cells of the vago-accessorius nucleus at the level of the calamus scriptorius. Observe the marked chromatolysis and eccentric position of the nucleus. Compare the same with fig. 6. Magnification 400.

FIG. 6.—Cells of the adjacent hypoglossal nucleus, showing early slight chromatolysis. Magnification 400.

FIG. 7.—An arteriole breaking up into capillaries with dilated perivascular space. This space is in communication with the perineuronal space around the nerve cells. Magnification 300.

FIG. 8.—Section of cortex, Case 2. Dilated perivascular space around collapsed arteriole and capillaries. Dilated perineuronal spaces. Magnification 375.

FIG. 9.—Cortical cells from Case 2, showing swelling and chromatolysis of cytoplasm and clear swollen nuclei. Magnification 400.

FIG. 10.—Section of cerebellum, Case 1, stained with polychrome and eosin. Note the Purkinje cells are not all similarly stained. Two are stained faintly with the basic dye; the remaining ones are stained with the acid dye indicative of a chemical change. Magnification 270.

FIG. 11.—Medium sized anterior horn cells in first lumbar segment; a microscopic hæmorrhage is seen near, the Nissl granules have almost disappeared in the cells, and the staining is diffused and uniform without the displacement of the nucleus. Magnification 330.

FIG. 12.—Hæmorrhage, the size of a small pin's head, at the base of the posterior horn; the tissues around are fractured and retracted, but this may be in part due to the action of the fixing fluid. Magnification 185.

FIG. 13.—Two large anterior cornual cells from the third lumbar segment showing fairly well marked perivascular chromatolysis; the nucleus in one is eccentric and the nucleolus cannot be seen. Magnification 360.



CHADWICK LECTURE (APRIL 26TH, 1917):\*  
MENTAL HYGIENE IN SHELL-SHOCK, DURING  
AND AFTER THE WAR.(1)

By F. W. MOTT, M.D., LL.D., F.R.S., MAJOR, R.A.M.C.T.

MR. PRESIDENT, LADIES AND GENTLEMEN,—A new epoch in military and medical science has arisen in consequence of the employment of high explosives, combined with prolonged trench warfare, in this terrible war.

The term "shell-shock" is applied to a group of varying signs and symptoms, indicative of loss of functions and disorder of functions of the central nervous system, arising from sudden or prolonged exposure to forces generated by high explosives. The forces producing shell-shock are most commonly generated by the explosion of large shells, but also of mines, aerial torpedoes, whizz-bangs, trench mortars, bombs, and hand-grenades filled with high explosives.

In a large number of cases, although exhibiting no visible injury, shell-shock is accompanied by burial. Again, cerebral or spinal concussion may be caused by sand-bags, hurled from the parapet or parapets of the trench, striking the individual on the head or spine. The soldier may be concussed by the roof or wall of the dug-out being blown in, or he may be driven violently against the wall of the trench or dug-out, or blown a long distance, simply by the strength of the explosion.

One case in point: An engineer officer under my care recollected nothing of the circumstances of the shell-shock which brought him to hospital, but a brother officer informed me that he was blown 40 feet along a road by the explosion of one shell, and blown back again by the explosion of another. The enemy was "strafing" the road by planting shells along it at intervals.

\* Reprinted by arrangement with the Editors of the *Journal of Mental Science* (October, 1917).

It has been shown that the force generated by 17-in. shells is equal to 10,000 kgrm. per square metre, or 10 tons to the square yard. This supports the contention that even death may occur as the result of aerial concussion, generated by high explosives, without visible injury. I think probably the cause of death in such a case would be sudden arrest of the vital centres.<sup>(2)</sup> The stem of the brain, surrounded by the cerebro-spinal fluid, is prevented from oscillating by the anterior and posterior roots and the ligamentum dentatum. The cerebro-spinal fluid, therefore, acts as a water jacket to the spinal cord, and water cushion to the base of the brain. A sudden shock of great intensity would be transmitted through this incompressible fluid, and, seeing that it not only surrounds the central nervous system, but fills up the hollow spaces, ventricles, and central canal, and all the interstices of the nervous tissues, it follows that a shock of sufficient intensity communicated to the fluid would occasion *commotion* of the delicate colloidal structures of the living tissues of the brain and spinal cord. Such commotion would certainly lead to disordered function, and if severe to loss of function. The higher centres are the most likely to be affected; therefore consciousness, memory, sensory perception, and speech suffer. If the commotion is sufficient to arrest the functions of the vital centres in the medulla, instant death would ensue, but it is difficult to determine in many cases whether the force was delivered by the hurling of a sand-bag against the head or spine, or simply by aerial concussion in a confined space.

This leads me to call your attention to another important factor which may complicate the condition termed "shell-shock." The soldier, while lying partially buried and unconscious, or at any rate helpless, may be exposed to various noxious gases,<sup>(2)</sup> generated by shells or mines, especially carbon monoxide, or oxides of nitrogen, both of which are poisonous by reason of the de-oxygenating effects upon the blood. Other poisonous gases from shells may produce most injurious and even fatal results; *e.g.*, cyanogen compounds, phosgene, which is chloride of carbonyl and chlorine, etc. Both these gases are very deadly in their effects.

From the point of view of compensation or pension, the War Office authorities very properly regard shell-shock as a definite injury; still, from my experience, I have formed the opinion that the term "war neurosis" would be better for the

majority of cases now sent back diagnosed as "shell-shock," because the signs and symptoms of these in no way differ from cases of neurasthenia and hysteria, occurring even in soldiers who have never been exposed to shell-fire, but have experienced the emotional shock of fear, and apprehension of what will happen to them, if they are exposed to the terrors of shell-fire and trench warfare.

Another objection to the term "shell-shock" is its elasticity, rendering it liable to be differently applied by different medical officers. I have observed that some medical officers avoid the term as far as possible, and I am always suspicious of the soldier who, when asked what he is suffering from, glibly informs you "Shell-shock, Sir." I am apt to believe he is "shell-shy." I agree with Major Hurst that it would be better if the term "shell-shock" was more limited in its application, and it should not be employed in cases of neurasthenia, hysteria, or fear, causing a man to be sent back, although he has only been subjected to the experiences of war which every soldier must undergo who goes to the Front. *The term "shell-shock" should, from a scientific point of view, be applied to those cases where there is definite evidence of commotion or concussion of the central nervous system.*

Malingering as shell-shock is, I am informed by Capt. William Brown, quite common at the Front, and the detection of conscious fraud is not easy in many of these cases, owing to the fact that a functional neurosis, due to a fixed idea or obsession, inhibiting will power, may be mistaken for malingering. Again, the notion of never recovering tends to become a fixed idea, and this fact is of considerable importance in respect to the discharge from the Army "permanently unfit," and the subsequent payment of pension and compensation. It is essential to be sure of your diagnosis that the disease is altogether functional, and, being satisfied thereof, to avoid all forms of suggestion of non-recovery.

*Mental and Bodily Condition of the Individual at the time of receiving the Shock.*

In considering the effects of shell-shock on the nervous system, it is necessary to call attention to a complex of factors of extrinsic and intrinsic origin, apart altogether from the

effects produced by direct material injury to the central nervous system by commotion and concussion. I will now consider the extrinsic conditions in modern trench warfare, which lead in a neuro-potentially sound individual to nervous exhaustion, predisposing to shell-shock. It must be obvious that through all the sensory avenues, exciting and terrifying impressions are continually streaming to the perceptual centres in the brain, arousing the primitive emotions and passions, and their instinctive reactions. The whole nervous system, excited and dominated by feelings of anger, disgust, and especially fear, is in a condition of continuous tension; sleep, the sweet unconscious quiet of the mind, is impossible or unrefreshing, because broken or disturbed by terrifying dreams.

Living in trenches or dug-outs, exposed to wet, cold and often (owing to shelling of the communication trenches) to hunger and thirst; dazed or almost stunned by the unceasing din of the guns; disgusted by foul stench, by the rats and by insect tortures of flies, fleas, bugs, and lice, the minor horrors of war, when combined with frequent grim and gruesome spectacles of comrades suddenly struck down, mangled, wounded or dead, the memories of which are constantly recurring, and exciting a dread of impending death or of being blown up by a mine and buried alive together constitute experiences so depressing to the vital resistance of the nervous system that a time must come when even the strongest man will succumb, and a shell bursting near may produce a sudden loss of consciousness, not by concussion or commotion, but by acting as the "last straw" on an utterly exhausted nervous system, worn out by this stress of trench warfare and want of sleep.

In considering the effects of shell-shock, it is necessary to take into account, the state of the nervous system of the individual at the time of the shock caused by the explosion. As I have indicated, a neuro-potentially sound soldier may, from the stress of prolonged trench warfare, acquire a neurasthenic condition, and it stands to reason that a soldier who is already neurasthenic from a previous head injury, or from acquirement of a disease, prior to his being sent to the Front, will not stand the strain so well as a neuro-potentially sound man.

Of even greater importance than the extrinsic conditions in the causation of military unfitness from exposure to shell-fire, are the intrinsic conditions, for if there is an inborn timorous

or neurotic disposition, or an inborn or acquired neuropathic or psychopathic taint, causing a *locus minoris resistentiæ* in the central nervous system, it necessarily follows that such an one will be unable to stand the terrifying effects of shell-fire and the stress of trench warfare. A large number of the cases of shock which I see in hospital and which especially require treatment by mental hygiene are neuro-potentially unfit.

They come back after a short experience at the Front, suffering with neurasthenia or hysteria, which persists for months and even a year or more; these are temperamentally unfit.

To take two concrete examples of the importance of the personal factor in the consideration of the causation of shell-shock. A commercial traveller with one year's training, three weeks in France, and three days in the trenches, was sent home suffering with shell-shock; after six months in hospital he is still tremulous and hardly able to stand or walk. He has done his best, but has cost as much as a cartload of shells. Compare the personality of this man with another, who was also admitted under my care suffering from spinal concussion, paralysed in all four extremities, with loss of control over his bladder and bowels. The history he gave was that he was in a dug-out when an 8-in. shell burst 2 ft. behind the dug-out; he was partially buried, but did not lose consciousness; when he was rescued he was found to be paralysed. Now this man shows none of the signs of shell-shock; he has no terrifying dreams, and although the concussion caused a hæmorrhage into his spinal cord, followed by degeneration of the pyramidal tracts (*viz.*, the paths of volitional impulses), nevertheless he is making a splendid recovery, and in two months is much less helpless than most of the severe functional cases of paraplegia, in which the paralysis of the legs is due to a fixed idea that they are unable to walk or stand. He appeared to be insusceptible to emotional shock. The case of another man under my care however, illustrates remarkably well the effects of emotional shock (psychic trauma) in the production of a profound effect upon the central nervous system. He was sent out with a party to repair barbed wire, when a great shell burst among them, blowing him into a shell-hole; he scrambled out; seeing his comrades mangled and dead, he fell down and recollected no more of what happened for some weeks. When admitted

under my care, he presented a picture of abject terror, reminding one of the lines in Spenser's *Fairie Queen* :

“ He answered not at all, but adding new fear to his first amazement,  
Staring wide with stony eyes and hollow hue,  
Astonished stood as one who had espyed  
Infernal furies with their chains untyed.”

As we know, one of the peculiarities of the functional neuroses, *e.g.*, hysteria, is not only the sudden manner in which an emotional shock may cause a loss of function, but likewise the sudden manner in which it may be unexpectedly restored by a stimulus of the most varied kind, provided there is an element of surprise. That is, his attention is for the moment taken off its guard. I am referring especially to hysterical mutism and aphonia. If the patient is neuro-potentially sound, he will recover as a rule from shell-shock by rest of the mind and body under healthy conditions without any special treatment. But the neurotic, the neuropathic and the psychopathic individual, with an inborn or acquired *locus minoris resistentiæ* in the central nervous system, is more difficult to treat successfully, for when an inborn or acquired predisposition to a neurosis or psychosis exists, functional disorders or disabilities of the nervous system tend to become organised by habit, and eventually firmly installed.

Before we consider the mental hygiene of shell-shock, it is necessary to point out the more important signs and symptoms, for although the general principles of treatment are the same, special functional disorders and disabilities necessitate special methods.

#### *The Effect of Shell-shock on Consciousness.*

Most of the severe cases have suffered from loss of consciousness, or they have no recollection of what happened after the shell burst and till they were at the clearing station or hospital ; it does not follow that they were in a state of complete unconsciousness during that time, for cases have been recorded where under hypnotic suggestion they have been able to revive in consciousness some of the forgotten events. Again the following case rather tends to show that often instead of complete unconsciousness loss of power of recollection seems to be the effect produced on consciousness by the shock. Several



cases of the kind have come under my notice, but I will describe one of the most reliable, as it is a history that came from an officer. His company dug themselves in in a wood ; he went out into the road to see if a convoy was coming when a large shell burst near him. It was about 2 a.m. and quite dark ; about 4.30 a.m. it was quite light, and he found himself being helped off his horse by two women who came out of a farm house. He had no recollection of anything that happened between the bursting of the shell and this incident. It is interesting to know that it is possible for him to have inhaled noxious gases, for the single cigarette in a metal case that was in his breast pocket was yellow on one side, due, no doubt, to picric acid contained in the explosive.

Many cases have been admitted under my care at the Neurological Section of the 4th London, who had not yet recovered normal consciousness, and for some days were in a dazed, somnolent or even semi-conscious condition. Usually these cases came at a time when large convoys were sent from the Front owing to a recent engagement. The histories of cases sometimes showed that men absented themselves as a result of shell-shock, and, wandering away from the trenches, were found in a dazed condition, unable to account for their actions or to recollect how they came there. This condition is not unlike a fugue or automatic wandering of an epileptic ; and, indeed, in some of these cases there was a history of epilepsy or a predisposition to it, but in others no other cause was ascertainable than the conditions which induced shell-shock.

A good many patients say that they can picture in their mind's eye the shell coming ; they visualise the death and destruction caused, and they can revive in memory the sound of the explosion, but a blank of variable duration in their recollection of events follows. Many of these patients have not really suffered with either cerebral commotion or concussion, and in strict acceptance of the term are not true shell-shock cases. Cases of severe concussion or commotion have an anterograde as well as a retrograde amnesia, and these cases may sometimes show such a complete loss of memory of any event in their past life that they do not know their own name or where they live ; in fact, their recollection is a blank, as if the commotion had obliterated the store house of the mind and its contents. In these cases it is quite probable there has been

either an additional factor of concussion or burial with gassing.

Some of the severe cases of amnesia we know were gas poisoning complicated by concussion or burial. However, it is as well to bear in mind that when a man professes a complete loss of memory, otherwise showing no signs or symptoms of shock, he may be suspected of malingering. Cases have been admitted to hospitals, and diagnosed as shell-shock, because they are unable or pretended to be unable to recollect their names or where they came from, who have never been out of the country. I am informed by Capt. William Brown, who is neurological expert with the 4th Army, that hypnotism is very useful in detecting such malingerers, and the fear of giving themselves away has a deterrent effect on this form of malingering, whether it be deserting their post or deserting the ranks and professing inability to recollect what has happened.

The drowsy anergic stupor which many of these patients suffer from may disappear gradually; or it may be associated with auditory or visual hallucinations of a terrifying nature—day dreams of the terrible experiences they have gone through. As the mind becomes more conscious of the external world, these day dreams are screened off and as a rule are not able to pass the threshold of consciousness; but I have had cases where quite suddenly and unexpectedly terrifying visual hallucinations have induced all the external manifestations of fear, *e.g.*, profuse sweating, a wild terrified look and attempt to escape by flight, and when prevented from doing so, fear gave place to maniacal excitement and desperate struggling to escape. Some of the cases are obsessed with a terrifying experience; for example, one soldier kept shouting out that he saw "ginger-headed Fritz," it turned out that this was a German sniper of renown. Another felt a patch of blood on his cheek, and when a mirror was held in front of him and he was shown that there was nothing there, he said he felt it was there although he could not see it. Asked how it happened, he said that a Prussian Guard had stabbed his sergeant in the neck with a saw bayonet, and when the Prussian drew it out the blood spattered all over his cheek. Now, although as a rule, in most cases these terrifying experiences do not come up into consciousness during the daytime when the mind is occupied in reacting to the constant perceptual chain of events, yet if the mind is not diverted from introspection,

these terrifying experiences are always ready to obtrude themselves on consciousness, and this is clearly shown by the fact that one of the most constant, most serious and disturbing symptoms of shell-shock are the terrifying dreams which are seldom, if ever, absent, although sometimes they cannot be recollected, but in such cases although the patient does not recollect the dream he will tell you that he has been awakened in a cold sweat and has experienced the feeling of sinking or falling; this may be due to relaxation of muscles in consequence of fear.

### *Sleep and Dreams.*

Insomnia, and sleep disturbed by terrifying dreams, afflict nearly all cases of shell-shock and war neurosis. I have not found any evidence supporting Freud's views. I have questioned a number of officers and men, and have asked them to write confidentially their dream recollections. Very seldom indeed do they refer to any reminiscences of childhood. They almost always tell the same story of dreaming of their recent experiences in the trenches. Shakespeare has clearly indicated how dreams influence the minds of men, and how they are based upon past experiences. Thus, Mercutio, in the description of Queen Mab, refers to the soldier's dream in the following lines, which are as true to-day as when Shakespeare wrote them :

“Sometime she driveth o'er a soldier's neck,  
And then dreams he of cutting foreign throats,  
Of breaches, ambuscadoes, Spanish blades,  
Of healths five fathom deep; and then anon  
Drums in his ear, at which he starts and wakes;  
And, being thus frightened, swears a prayer or two,  
And sleeps again.’

In addition to the revival of experiences of trench warfare, of hearing the shells burst and seeing the flash, of parapets being blown down, of being buried, of charging the enemy, soldiers often complain of a falling or sinking feeling; possibly it is to this that Shakespeare refers in the lines, “Of healths five fathom deep.” Often, in their dreams, soldiers are heard to cry out; and officers have been heard to give commands to their men, and urge them on to battle.

I have had four or five cases of soldiers who, in their sleep,

have gone through the pantomime of fighting with the bomb, with the bayonet, and with rifle. In consequence of the danger of injuring themselves in their unconscious but violent purposive motor activities, it sometimes became necessary to place them on a mattress in a padded room. Sometimes soldiers, when placed under an anæsthetic, have been known to perform the pantomime of habitual acts, as of raising the gun to the shoulder, and pulling the trigger.

The ancients were fully aware of this, thus Lucretius says : "Again the minds of men which pursue great aims under great emotion often during sleep pursue and carry on the same in like manner, kings take by storm, are taken, join battle, raise a loud cry as if stabbed in the spot." "*De rerum natura*." —Munro. Sometimes the same terrifying dream recurs night after night, causing great mental distress. An officer told me that he had two dreams based upon two separate experiences which constantly recurred ; one was attended the next day by a feeling of mental depression, the other by a certain degree of exhilaration. The former was the sight of the legless body of a Prussian that lay for days in front of their dug-out, and which it was impossible, and highly dangerous, as they had found to their cost, to move. The latter was his escape from a death struggle. He was in a trench, a Prussian threw a bomb at him, which just missed him, and exploded out of harm's way ; he then threw a bomb, and it blew the enemy's head off, just as the Hun was preparing to throw another at him.

When these dreams cease, the patient is getting better. They are indicative of terror, which is contemplative fear continued and fixed in imagination, and the signs and symptoms these patients suffer from are largely due to the continued effect of fear on consciousness. It is obvious that this fact is all important to bear in mind when considering the mental hygiene of shell-shock. The principal objective signs and subjective symptoms of shell-shock largely correspond with those of paralytic fear. We speak of being paralysed by fear, of giving way of the knees, of trembling or quaking with fear, of being dumb with fear, of 'blue funk.'

All these popular expressions regarding the influence of the emotion of fear on the human body are based upon actual experience, for paralysis, tremors, giving way of the legs,

mutism, and cold blue hands are among the most constant signs of soldiers suffering with shell-shock.

*The Influence of Fear on Phonation and Speech.*

A frequent condition met with is aphonia and mutism or inability to speak even in a whisper. This in no way differs from hysterical aphonia and mutism.

It is the conscious mind operating on the centres in the brain controlling phonation which causes this affection of speech, for mutes often shout in their sleep, and this may be the prelude to the recovery of their speech ; one man recovered his speech on being told that he had been talking in his sleep by a comrade who slept in the next bed ; he was so suprised that he said, " I don't believe it." Another man recovered his speech when pitched out of a punt on New Year's Eve ; he had been mute for more than six months. This lad could not whistle, could not phonate in coughing, could not blow out a candle, yet he was heard to shout in his sleep. An X-ray examination of his chest showed that the diaphragm hardly moved even when he made a great effort ; the fear effect on his conscious mind had inhibited the respiratory movements necessary for phonation and the idea had become firmly installed in his mind. Breathing exercises to relax the contracted respiratory muscles may be usefully employed in some of these cases, and I have had two lady helpers (Miss Oswald and Miss Bush), teachers of elocution and singing, who have done excellent service. The latter has organised singing-classes, and it is astonishing how helpful these have been in restoring phonation and in curing speech defect, such as stammering, stuttering, mutism, and aphonia, by spontaneous imitation.

*Mutism with Deafness.*

Mutism is often accompanied by deafness ; sometimes the patient recovers his speech and remains deaf. I have had a great number of cases of mutism and mutism with deafness, and in only one instance have I been unable by suggestion or other means to restore the function. A particularly intractable case came to the hospital, who had been deaf and dumb for nearly a year ; I tried strong electric shocks, tuning-forks to the head, and sudden noises and hypnotism, without any result, but Dr. Yelland, of the National Hospital, Queen Square, cured

this man. I think the imposing array of electrical machines, coloured lights, and other strong suggestive influences, were partly instrumental in accomplishing what I had failed to do, but also I think the knowledge of success in other difficult cases, attending Dr. Yelland's effort, played a very important part in curing by strong suggestion this apparently hopeless case.

To illustrate the value of suggestion in this particular class of case, I may select another incident. I told a man, who was deaf and dumb, and had been so for some time, that he would recover his hearing and speech on a particular day. When I visited the ward on *the* day, I said: "Sister, does D— speak?" "No," she said; "but he was heard to speak in his sleep." I saw a way out of my difficulty, for I wrote down: "You spoke last night in your sleep; you will certainly recover." Now this man, impelled by dreams, used to go through the pantomime of bayoneting Turks in the trenches, of which he was quite unconscious in the morning. He fell out of bed while doing this, cried out, and awoke, having recovered his hearing and speech. Sometimes the men do not want to recover the speech too quickly, and speak only in a whisper. When I have thought a patient was thus consciously prolonging his disability, I have said to the sister aside, but loud enough for the patient to hear: "This man must be kept in bed on No. 1 diet, and when he can ask loud enough for you to hear, he can have a bottle of stout and a mutton chop." I have had several get well the next day by this treatment.

#### *Hysterical Sensory Dissociation.*

The deafness may be partly functional, partly due to injury of the drum of the ear, or wax may be damped against the drum. Only about 17 *per cent.* of the cases of deafness are really due to, or partly due to ear disease; the majority of the cases are purely functional, and due to dissociation of the sensory perceptive centres of hearing of the brain. They do not hear the tuning-fork, although they feel the vibration. There is usually dizziness, but there are signs which clearly serve to differentiate this functional cortical brain deafness from the deafness due to damage of the organ of hearing and equilibrium, or the nervous structures in it.

Sometimes a man is blind, and an examination of the eyes shows that there is no injury or cause in them to account for

the loss of sight. Vision may be lost suddenly and restored suddenly ; suggestion plays an all-important part, not only in dissociating the visual perceptive structures in the brain from the nervous tracts which convey the light stimuli of the blinding flash from the eyes, but in restoring the sight by re-associating them. Again darkness may by suggestion cause blindness, as was shown in the following case. A man suffering with shell-shock, crept into a culvert and lost his sight there, so that he was unable to find his way out ; a wounded man came in, and by their combined efforts they got out ; the blind man carried or helped to support the wounded man, and the wounded man directed the blind man.

Another interesting case was that of a grenadier who was blind, deaf and dumb, and this case like many others I have seen, illustrates the fact that, when an individual is deprived of the use of one or more of the sensory perceptive centres of the brain, the mind is more alert in receiving stimuli arriving by the remaining avenues. Thus, this grenadier who was quite blind, deaf and dumb, was most sensitive to touch, so that he started back when the feeding cup was put to his lips. The day after admission he had an hysterical fit, owing to abdominal pain, and suddenly recovered his sight. The next day he was able to write down his name, regiment, native place, etc., but of his experiences in France he knew nothing, although he had been out a considerable time. He was very distressed that he could not hear or speak. A few days later he had another emotional outburst, and thereafter recovered his speech and hearing. We subsequently found that he had been blown up and buried by a shell, but of this he had no recollection. He made a rapid recovery. This was a true case of shell-shock, causing a functional neurosis by disassociation due to commotion of the brain.

Here I may say how important it is to ascertain how long a man has been in the front line in estimating how much of the functional disorder or disability is due to a pre-war neurotic condition.

#### *The Differential Diagnosis of Shell-shock.*

Shell-shock is a term applied to severe forms of war neurosis, usually associated with *commotio cerebri* or concussion, and not infrequently attended by burial and the

inhalation of poisonous gases while lying buried or unconscious. The shock may be so severe as to cause instant death by arrest of the vital centres in the medulla, or complete loss of consciousness may supervene of varying duration. Upon the return of consciousness the patient may be unable to recollect past experiences for a variable period of time ; there is a retrograde amnesia, sometimes so complete as to leave the whole past a blank. In severe cases, instead of a complete restoration of consciousness, there may result a condition of deep anergic stupor, which may in rare instances continue for weeks and months ; more frequently there is a dazed, somnolent condition, associated with mutism, and a vacant, mindless, apathetic expression in the eye and face ; the stuporose state is accompanied by an emotional indifference to surroundings. The depth of the amnesia is reflected in the expression of eye and face, and the malingerer is usually unable to simulate successfully the mindless expression, which is associated with a complete loss of memory, for he generally overacts that part of the business which lies within his conscious power to overact. Sufferers with "shell-shock" may wander in a dazed condition and not be able to recollect what they have been doing or where they have been. They may not even know their name. Sometimes a maniacal delirium ensues and they may become homicidal or suicidal. One of my patients aimed his rifle at his commanding officer ; it was recognized that he was not responsible for his acts and was evacuated. He was quite sane when he arrived in England.

Cases of exhaustion psychosis have been mistaken for dementia præcox ; especially when, associated with the stupor, there have been auditory hallucinations, fragmentary delusions, mental confusion, and outbursts of impulsive violence. I have seen patients, even thus afflicted with such serious symptoms of mental disorder, get well. Consequently, when there is a history of shell-shock, or a reasonable belief that the patient has suffered shell-shock, it is well to wait before giving a bad prognosis. Two youths, under my care for months, suffered from anergic stupor, and recovered ; it was curious that when speech returned, their language in mode of utterance and modulation of the voice, was like that of an infant. When asked how they felt (although in hospital at different times), they each gave the answer in the same way—"me bet-tah."



An exhaustion psychosis from shell-shock may be associated with a restless, choreiform, motor delirium; several of these patients had suffered in early life from chorea. Some of the patients suffering from psychasthenia are troubled by one or other of various phobias; the commonest of which are claustrophobia and agoraphobia. All patients with shell-shock complain of inability to concentrate their attention, and they are easily fatigued by mental or bodily effort; some of them suffer with asthenopia; nearly all complain of headache, occipital, frontal, or through the temples. Hyperacusis and being startled by noises, is usually present. Tremor of the hands is usual, less often of the upper lip and of the legs. The knee jerks are exaggerated, otherwise normal. The pupils are equal and react normally. Various tics are common, a frequent form being a defensive "dodging reflex" of the head.

Of the various types of neurasthenia associated with shell-shock, the spinal, cardiac, cerebral, and gastric were the most common.

Only a few of the cases relatively suffered with signs and symptoms of sexual neurasthenia; where sexual neurasthenia occurred, the cases were usually of men who had not been at the Front, or if they had, had not remained there long.

The symptoms of the spinal type were, generally speaking, the result of suggestion; *e.g.*, the patient had received a blow on the back, or a superficial wound of the spine, or there was a history of burial. In addition to the usual group of neurasthenic symptoms, there was pain and tenderness of the spine and tremor and giving way of the legs, and not infrequently functional paraplegia, or a condition of astasia-abasia (inability to stand or walk, although able to move all the joints of the legs while lying in bed). The abdominal reflexes are normal; the sphincters are unaffected and the plantar reflex is flexor.

The cardiac form of neurasthenia also is common. Such cases have frequently been labelled D.A.H. as a systolic murmur has been discovered. The knowledge of this has in many cases led to a concentration of the mind on the precordium; they feel pain and discomfort in the region of the heart; they suffer with palpitation and breathlessness on exertion; and in some cases there is a non-conducted systolic murmur and physical manifestations of dilatation. The heart's action in these cases is rapid, 120-160 (tachycardia); it is accelerated

by emotion and apprehension, but mental diversion will diminish it. The pulse has sometimes been markedly diminished in frequency when I have taken the patient's mind off himself by asking him to pull against me.

It is of great importance to gain the full confidence of the patient by making a thorough examination in these visceral neuroses the better to be able to assure them that their organs are not diseased, and that the symptoms they are suffering from and which alarm them, are due to nervous exhaustion and apprehensive contemplation by the mind of the vital organ. As Dejerine truly says : "*C'est la foi qui sauve—ou qui guérit.*"

#### *Treatment of Shell-shock in the Early Stage.*

I am informed by medical officers at the clearing-stations that there is an increase of pressure of cerebro-spinal fluid in true shell-shock cases, and that sometimes even it is blood-stained or contains albumin; also that relief of symptoms occurs by withdrawing fluid by lumbar puncture.

The *treatment* of cases of shell-shock varies to some extent in different individuals, according to symptoms and signs, but there are some symptoms which are seldom absent in all true cases, *viz.*, insomnia and terrifying dreams. I have found the continuous warm bath of great value in the treatment of these cases when they come over from France. The water in the baths is kept continuously at the temperature of the blood by a special mechanism of heat regulation; the patients are kept in the bath for a quarter to three-quarters of an hour, or even longer. The effect is most soothing on the nervous symptoms, and one can understand how it is so from the fact that the whole of the sensory nerves of the skin are acted upon by the warmth; the tired muscles are relaxed, and the blood is withdrawn from the internal organs, including the brain, to the skin. These baths are extremely useful in cases of maniacal excitement. Often the bath, with a drink of warm milk at bed-time, suffices without hypnotics to produce sleep. But if hypnotics have to be given, the quantity required is less when combined with the baths. The hypnotics I recommend are trional, gr. x—gr. xv, preceded by mist. paraldehyde ℥ij, or this alone. Pot. brom. or chloral, of each 15 gr., and either tinct. opii ℥xv., or tinct. cannat. ind. ℥x. Dial two  $1\frac{1}{2}$  gr. tablets. In maniacal

excitement hyoscin in  $\frac{1}{75}$ – $\frac{1}{100}$  gr. doses hypodermically. It is better to avoid drugs if possible, but sleep is indispensable. The next thing is to attend to the general bodily condition by nourishing, digestible, and easily assimilated food ; and lastly, very important is attention to the primæ viæ, by which auto-intoxication and cerebral congestion can be relieved. A dose of calomel and saline in the morning is the usual practice. The severe headache from which these patients suffer, requires relief by an ice-bag to the head, aspirin, phenacetin, and other drugs which relieve neuralgic pains.

After the patient has recovered from the more serious condition of shock, and the mind is becoming more alert and interested in its surroundings, we have to consider how best to allay the symptoms, which nearly all suffer from, *viz.*, headaches, dizziness, tremors, feeble circulation, and exhaustion, readily brought on by mental or bodily effort. As a sedative and nerve tonic I usually prescribe dilute hydrobromic acid, quinine, and strychnine. I have found pituitrin useful in cases of low blood-pressure. When the symptoms point to hysteria, bromide and ammoniated tincture of valerian are prescribed. If the patient is sufficiently well to sit up, it is better that he should do so, at first for a few hours a day, if possible in the open air. To severe cases, the noise of gramophones, pianos, the click of billiard balls, and even musical instruments, excite and aggravate symptoms ; quiet repose in single rooms, such as we have at the Maudsley Hospital, is undoubtedly a most important and necessary mode of treatment in the early stages of severe cases.

At the same time these patients should not be left alone ; quiet and unstimulating diversion of mind should be encouraged to avoid introspection and dwelling upon the terrible experiences they have gone through. These men are often too tired or unable to read on account of inability to concentrate attention, and fatigue of the muscle of accommodation and the mind may be diverted by simple games, knitting or wool work bead work, basket work, and net-making.

#### *Mental Hygiene in Later Stages.*

As soon as they are better, patients are encouraged to play billiards, cards, and other games, in the winter time especially ;

also there are frequent concerts and popular lectures, all of which serve to divert the mind and produce an atmosphere of cure which is very essential. Soldiers will put up with a good deal provided they have good and abundant food, and it is essential for recovery that there should be no grouching.

Grumbling and grouching are contagious, and it is always well to get rid of a soldier from a ward if he is exciting discontent in the others. Discipline is very essential; laxity of discipline, over-sympathy and attention by kind well-meaning ladies giving social tea-parties, drives, joy-rides, with the frequent exclamation of "poor dear," has done much to perpetuate functional neuroses in our soldiers. The too-liberal gifts of cigarettes has produced a cigarette habit in officers and men, which is highly detrimental in these cases of war neurosis, especially in cases of irritable-dilated heart, or in cases of cardiac neurasthenia.

Again, in many cases of functional paralyses, the idea of a permanent disability requiring pension for the rest of a man's life may become a fixed idea, owing to wrong diagnosis, over-sympathy, and misdirected treatment. In many of these cases, as I have found, what is required is merely strong\* suggestion to the patient that there is nothing the matter with him except the idea that he is paralysed, which has become installed and firmly fixed in his mind, by prolonged bed, with daily massage, and electricity, which has kept suggesting to him that there is an organic disease causing his complaint. I have seen many cases of inability to stand or walk, who yet could move their legs in bed, and by the tests I have described exhibited conditions definitely pointing to functional paralysis and not to organic disease. Being thus sure of my ground, I have told the patient to get up, and I would support him and see that he did not fall. I have then engaged his attention by asking him questions about himself and his former life while gradually relaxing my hold, until he was standing without any support. After a little while, I say to him, "Now, you did not know that you have been standing about five minutes without any support." I have often succeeded in making such a patient walk. Men have come who have been using crutches for a long time, and I have told the sister to take the crutches and put them in the museum, for this patient did not want them. Functional paralyses with contracture of long duration have been cured by

strong suggestion and manipulation by relays of operators to fatigue the contracting groups of muscles. Thus a case of prolonged talipes equino-varus was cured by continually placing the foot into position for hours together. At the end of three days the contraction was cured.

Sometimes, however, there may be so much trembling and shaking in the legs that the man is unable to walk without support. I induce him to try with sticks, and gradually get to one stick, and then to no stick, thus re-educating the muscles. Others come walking like quadrupeds, bending their backs and supporting themselves on two sticks: a little good-natured chaff and taking away the sticks has cured these.

Some patients, owing to an injury by a fall caused by an exploding shell, have developed a functional paralysis on the side of the injury, either arm or leg, or one of these limbs.

Supposing it is the arm that is so affected, I perform a number of associated movements of the two arms together—the healthy one and the paralysed—myself assisting the immobile arm, telling the patient at the same time to help me by thinking of the same movement. After a little while, he may be doing the main part of the movement himself. In all these functional paralytic conditions of an hysterical nature, a great tonic is to tell the patient that it is not at all likely that he will ever be sent back to active service, for he would be no use, and that what we want to do is to discharge him from the service in such a state that he will be fit to resume his previous occupation, or we can put him to some work useful to the State, whereby he will not be a burden to himself or the community.

I am quite sure that if this method were adopted early, in a large number of cases known by an expert to be temperamentally unfit for military service, a great economic saving would be effected.

Of course, precautions would have to be taken against malingerers. I am sure that machines employed by doctors as a means of making the functional paralytics move their limbs, are wrong in principle and in practice, and I entirely approve of the methods adopted by Col. Deane at the Croydon Hospital

\* Since this lecture was delivered I have found that the faradic brush combined with persuasion has been most useful. Often one séance has been sufficient to cure mutism and functional paralysis. The earlier a case of hysteria is thus taken in hand the more readily it yields to treatment.

of restoring function by natural methods, in which the mind is exercised. Thus, I had a boy with functional paralysis of the right arm; boxing and gymnastic exercises soon put him quite right. Col. Deane lays especial stress upon the value of associated movements, such as we get with the parallel bars, the climbing rope, skipping, football, Indian clubs, and the nautical wheel, and the ordinary apparatus of the old-fashioned gymnasium. My contention is, that this apparatus can be applied to any man who is capable of any movement. The inestimable advantage is, that his mind is projected into his paralysed limb, and all his sound limbs are being exercised at the same time. Constant change and adaptation is another advantage, especially when associated with mental occupation in the work. Diversion of the mind by useful occupation, both in the workshop and in the garden, have been most successful in restoring health and strength to these disabled men. Now, before discharging soldiers suffering from these functional neuroses, either as permanently unfit, or under C1 (garrison duty at home), C2 (agricultural work), or C3 (sedentary occupation), I always tell them that they must show themselves fit to to be discharged, by having so far lost their symptoms that when they do return to civil occupation, people should not say, "What are those blessed doctors doing in discharging a poor fellow in a condition like this"; and before they can leave the hospital they must give evidence of being in a fit state. I also tell them that I will prescribe for them two hours' occupation in the morning, either in the carpenter's shop or in the garden. This treatment I have been enabled to carry out through the generosity and kindly interest of Lady Henry Bentinck, who, at her own expense, has built in the grounds at Maudsley Hospital a large workshop fitted with every appliance for carpentering, cabinet-making, and metal work, and with a first-rate instructor. Numbers of officers and men are daily employed in this workshop, and almost daily Lady Bentinck comes to encourage them by her presence, and to supply any need for the successful prosecution of the work. The War Office pays for nothing.

Fortunately the Maudsley Hospital is situated in extensive grounds (for London), and the soldiers have, under my direction done much to beautify the waste that followed the building operations; they have even made a fountain and flower-beds, which

the King and Queen admired when they visited, and were greatly interested in. I might say here that the soldiers have built a poultry-house, and they are now hatching the eggs, in which process they take great interest. Since everybody has to grow vegetables, I have utilised a large amount of the garden for this purpose, but we should have been unable to have done this satisfactorily but for the prompt and generous manner in which Lady Bentinck purchased the tools required for a gang of twenty men, and also supplied the seed potatoes and other seeds necessary for cultivation.

As soon as the men show that they are fit to undertake work of this nature, we feel that they are sufficiently recovered to be discharged from the hospital under C2 or C3 ; but very often we find they suffer from dizziness or they easily tire, or say they suffer from dizziness or tire ; in fact they are not an energetic crowd, and many of them would prefer to patrol the Walworth Road or visit the cinemas. In the carpenter's shop the men receive such remuneration as the sale of the articles they make, less the cost, brings in ; orders for handicraft are received by the instructor. There are patients, however, who cannot stand the noise of the hammering and tapping.

#### *Agricultural Employment During and After the War.*

We have discharged a number of neurological cases to Bermondsey Military Hospital for auxiliary agricultural employment, and I have heard that this experiment has been successful. There are twenty-five acres of land at that hospital which can be utilised for agricultural purposes. The experiment, therefore, might be extended with great advantage, for I am convinced that occupation in the open air is a very beneficial mode of treatment of nervous cases in convalescent stage. It does not, however, always seem to be popular with a certain type of case. In commencing the treatment of convalescents by manual labour, it is essential to regulate carefully the character of the labour and the numbers of hours per day, and the work should be so arranged and graduated as not to induce more than that gentle sense of fatigue that promotes appetite, interest, sleep, and the general sense of well-being. Each case, therefore, has to be inquired into and the individual encouraged to take

interest. When a shell-shock case is discharged from the Service who by upbringing or inclination has a desire to work on the land, means should be provided whereby he can do so. The money he earns for his labour should be supplemental to the pension money or gratuity.

In concluding this lecture I feel it my duty to associate with the name of Chadwick as a pioneer of sanitary science the name of Maudsley as a pioneer of mental hygiene. This great philosopher and philanthropist gave a large part of his fortune eight years ago to the London County Council to build a hospital for the treatment of acute mental diseases, with a view of preventing them from becoming chronic and being sent to the county asylums. In the recent report of the Asylums Committee of the London County Council reference is made to the generosity of Dr. Maudsley, who is now over eighty years, in permitting the War Office to utilise it for the treatment of soldiers suffering from shell-shock and war neuroses, for which it is so admirably constructed and equipped. We only hope that he may live to see it utilised for the purpose he intended. When the King and Queen visited the Maudsley Hospital a few months ago they expressed themselves as very pleased with all the arrangements for the comfort and treatment of the many soldiers who have been sent over from France suffering from "shell-shock."

(<sup>1</sup>) Some abridgments and additions have been made, but practically the lecture remains as it was given, with the exception of a section on "Diagnosis," which would have been unsuited to a lay audience.—(<sup>2</sup>) Since this lecture was delivered I have had the opportunity of examining the brain of a man who died suddenly the day after he had been brought from the clearing station. He had been exposed to heavy shell fire; there was no history of gas or burial. There was no visible external injury, and Capt. Stokes, who made the *post-mortem* examination, from his findings came to the conclusion that the man had died of shell-shock. Microscopic examination showed no punctate hæmorrhages in the white matter which I have described as characteristic of gas poisoning, and which I have demonstrated as being due to thrombosis or embolism of terminal arterioles or venules. Nevertheless there were ruptured vessels in the medulla oblongata, the pons and the corpus callosum, and the condition of the heart and lungs showed that arrest of the cerebro-respiratory centres might have been the immediate cause of death. The full account of this case and another of death from the explosion of a large amount of cordite will be published shortly in the *Journal of the Army Medical Service*. The reader is also referred to a communication read before the Pathological Section of the Royal Society of Medicine entitled "Punctate Hæmorrhages of the Brain in Gas Poisoning," *Proc. Roy. Soc. Med.*, vol. x, Pathological Section.









